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Quantifying and Prioritizing the Maintenance of Planting Beds

At

Worcester Polytechnic Institute

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1. Introduction

Landscaping is the art of improving the natural beauty of a piece of land by planting or altering the contours of the ground. Landscape design is often used by an organization to visually represent itself to the community. The art and science of landscaping has been around for many centuries, dating back to ancient Roman, Japanese and Egyptian civilizations. "The oldest surviving garden plan -- for the garden of a court official in Thebes -- dates back to about 1400 B.C."[1] The zenith of landscape architecture and design was in 600 B.C. with creation of one of the Seven Wonders of the World, The Hanging Gardens of Babylon. Even today governments spend millions of dollars on landscaping to increase their stature and value by keeping their buildings striking to visiting tourists and diplomats.

Landscape design is also very important in the American Society. In the US alone, of the estimated $45 billion in U.S. horticulture sales in 2003, floral and nursery crops contributed one third, or $15 billion.[2] Not only is landscaping a multi-billion dollar industry but landscape and retail firms employ nearly 500,000 full-time, part-time, and seasonal workers. The importance of landscaping has grown substantially enough so that now 45 major universities offer a 4 year undergraduate program for landscape architecture. Ten of them also offer landscape and grounds keeping. All this time, money, and effort is spent so that each location has its own unique sense of character and

[1] http://artzia.com/Recreation/Outdoor/Garden/History/
[2] http://www.anla.org/industry/

identity. Landscaping can give a building the aura desired by the owner. Today, college campuses strive for this individual characteristic which is intended to appeal to prospective students.

Masterpieces such as New York City's Central Park, the grounds of the U.S. Capitol, and the plan for the 1893 Chicago World's Fair were all designed by Frederick Law Olmstead. Considered the founder of American landscape architecture, Olmstead and his firm designed Worcester Polytechnic Institute's campus in 1865. His plans were later completed in 1914 with the addition of the gymnasium. WPI prides itself in its beautiful and eye-catching campus. With the arrival of President Berkey, a lot work has recently been done to help improve the growing campus and its appeal to future students. The majority of the campus consists of perennials bordered by foreign annuals that have been expensive to maintain in the past. Over 20,000 perennial bulbs have been planted on the grounds over the past 6 years and 80-100 flats of annuals are planted on campus each year. Over $18,000 alone was spent last year on annuals in order to bring a wave of color during the spring, summer, and fall seasons. These beautiful annuals, like "New Guinea Impatiens," have been added in both the spring and fall to highlight certain campus hot spots, and to add color during WPI Commencement.

Since 2003, The WPI Plant Services Department has worked with two previous groups of WPI students in creating a new and efficient system of maintaining the campus grounds. The ultimate goal of having a successful landscape at WPI is to have brilliant color throughout the seasons. The two previous projects' foci have been working on the pathways and lawns of the university. Currently we have information about both previous

projects, along with the buildings and recreational facilities. Up until now, however, no one has taken into consideration the planting beds.

The objective of this project is to help the Plant Services team at WPI create an effective way of maintaining and preserving the campus's planting beds by developing a computerized way to plan and coordinate all of these services. The idea is to gather this information and plot out each bed, revealing the plants, their properties, and the tasks and costs for maintaining them. Our project will not only examine the flowers in the beds, but will also focus on the mulching techniques, pesticides, and fertilizer used by the groundskeepers. The planting beds must be mapped out, indexed, and plotted using the Geographic Information Systems. A plan must be developed with different levels of maintenance in order to make Plant Services' job easier and more efficient. After analyzing the information, we will strive to produce a successful plan for a continuously beautiful campus that is filled with color throughout the year at WPI.

2. Background

2.1. Landscaping Design and Architecture

"Landscape architecture is the art, planning, design, management, preservation, and rehabilitation of the land and the design of man-made constructs.[3]"

Landscaping design has been in existence since the establishment of the earliest civilizations in Egypt and Babylon. The Pharaohs of Egypt tried to design their pyramids such that they would be surrounded with flowers and palm trees. The Hanging gardens of Babylon, a major milestone in landscape architecture and one of the Seven Wonders of the World, was designed and created in 600 BC by Nebuchadnezzar II. A description of the detail of landscaping is found in this quotation,

> "The Hanging Garden has plants cultivated above ground level, and the roots of the trees are embedded in an upper terrace rather than in the earth. The whole mass is supported on stone columns... Streams of water emerging from elevated sources flow down sloping channels... These waters irrigate the whole garden saturating the roots of plants and keeping the whole area moist. Hence the grass is permanently green and the leaves of trees grow firmly attached to supple branches... This is a work of art of royal luxury and its most striking feature is that the labor of cultivation is suspended above the heads of the spectators".[4]

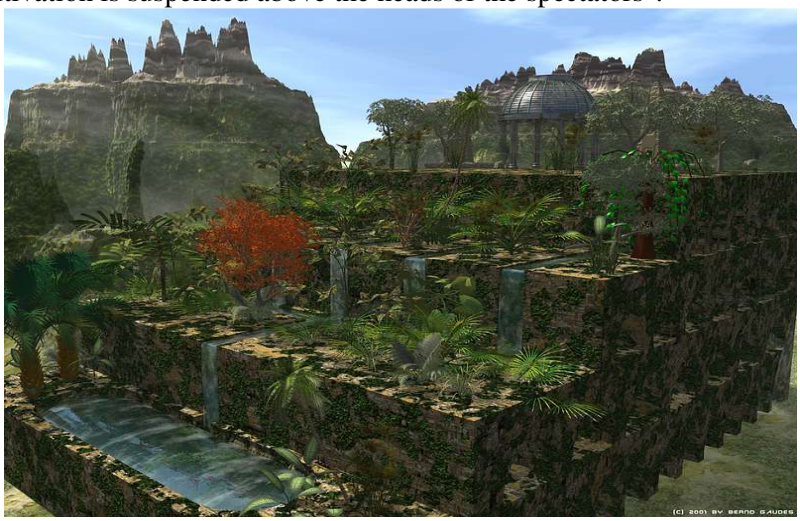

Figure 1: Digital Rendering of Hanging Gardens of Babylon

[3] http://en.wikipedia.org/wiki/Landscape_Architecture
[4] http://ce.eng.usf.edu/pharos/wonders/gardens.html

The term “Landscape Architecture” was mainstreamed in the modern era by Frederick Law Olmsted in 1858. Before Olmsted, an architect was known to design both the buildings and the spaces between them. But Olmsted planned city parks, complete urban open space systems, city and traffic patterns, subdivisions, private estates, and university campuses including the Worcester Polytechnic Institute.[5] Olmsted’s ideas were later followed by other people and the first complete program in landscape architecture was established at Harvard University in 1901. The American Society of Landscape Architecture was also founded in 1899 by five practitioners, four men and one woman.

Landscape Architecture was used to convey different ideology and philosophy. In the case of governments, Landscape was used to convey the power it reins over the people and place. Buckingham Place has one the greatest landscaping in modern times, which gives a feeling of awe and admiration to the observers.

Figure 2: Buckingham Place

[5] Michael Laurie 1986

University Campuses attempt to design their landscaping such that it gives a feeling of serenity to the faculty and students. But at the same time it should be attractive to the prospective students and visitors.

The landscape architect is hired by the owner of the land or his or her agent. The architect would then discuss the scope and the vision of the project with the owner. Next a landscaping team would survey the current condition of the land. The three primary areas of the initial analysis process as according to the author of "Landscape Techniques" says,

- The collection of data previously recorded, which is available and is relevant to the site under investigation and to the aims of the survey.
- The site survey, which will consist of the measurement of the physical characteristics of the site by means of instruments of various types.
- The visual and qualitative characteristics of the site, which will be dependent upon the observations of the surveyor. In the case of landscape surveys this can only be carried out successfully by a person trained to take not of biotic and visual qualities of a site and its surroundings. [6]

During the data collection of the site, the following information is usually taken into account:

- Topography
- Ecologic
- Geology and soils
- Access and circulation
- Provincial Climate

[6] A.E. Weddle 1979

After analyzing the data, the architect decides if the scope of the project is feasible with the budget given by the owner. Time is usually not a major problem for landscape architect because the flowers and plants are seasonal and can not be fast tracked. If it is not feasible, the landscape architect reports to the owner any potential alternatives. But if it is practical then the architect starts the design of the landscaping with the scope and compiled data.

Landscape architecture is clearly defined in four main practices.

- **Landscape evaluation and Planning,** this subject is mainly concerned with the systematic study of large areas of land and has a strong ecological and natural science base in addition to a concern for visual quality.
- **Site Planning**, this represents the more conventional kind of landscape architecture and within this realm lies landscape design
- **Detailed landscape design**, a process through which specific quality is given to illustrative spaces and areas of the site plan.
- **Urban Design**, a process of urban renewal and the construction of new towns.

2.2. Design of Planting Beds

When designing a planting bed, a garden, or a perennial border, one must first come to the realization that the task at hand can be very difficult. They can be long-term projects that are constantly shifting and adapting in order to reach the ultimate goal; a beautiful display of season long color. The first and most common problem that arises when designing a bed or garden is gaining a continuation of color when planting different species that will bloom at different times. Some plants can even outgrow their peers and can begin to take up their space.

The slogan for designing a planting bed is “keep it simple”. The first thing that should be taken into account is locating the bed, simply finding a space to lay plants. There are several key ingredients that make up an ideal location for planting such as finding an area that is open to the circulation of air; really humid areas can lead to problems in the future. Another obvious ingredient is a space where there is an abundant amount of sunshine so the plant can produce energy to live. However, a not so obvious ingredient lies within the ground: the soil. The soil conditions of the bed are vital. A well designed bed should be plotted over soil that is loose and open to the air where any moisture will reach the plants roots. Spacing is also important for the roots so that competition is held to a minimum. With all these ingredients to consider it is best that the location be worked out with paper and pencil first. This enables the planner to get an idea of the location, size, shape, and combination of plants that will work for the bed before he begins to dig.

After the planner has a firm grasp of what he would like to get accomplished on paper, they may then focus their attention on the finer details of what lies ahead. For

instance, James Underwood Crockett says “the width of the bed from the front to the back is very important in your plan, because the ease with which one can obtain continuous color in a bed increases in direct proportion to the width”.[7] It is easier to visualize it if you have a bed that is only 3 feet wide. Only 2 rows of plants will be able to fit accordingly in the bed. Yet, a bed that has 6 to 8 feet in width has enough room for as many as six different types of plants from front to rear. With the right plants, the bed architect can set it up so that the bed will have continuous color using the right combination of early, midseason, and late flowering species. Perennials and other plants for the most part look best when they are planted together in groups and even better when they are planted together in bold colorful groups. Also, having something solid in the background such as a building, or a wall will allow onlookers to focus their attention directly on the plants and colors rather than other elements of the environment.[8]

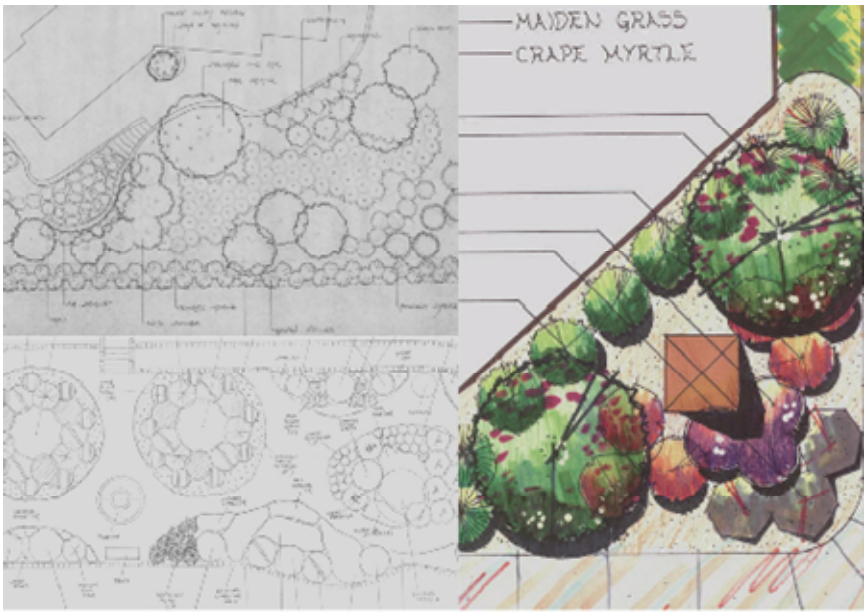

Figure 3: Example of Design

Ideally, if one can imagine their end goal in colors and shapes rather than plants and flowers, they have successfully constructed a planting bed. By

[7] Crockett, James Underwood. Landscape Gardening, Time-Life Books, Inc., New York, 1971
[8] Ibid

keeping it simple, the architect can focus on other important aspects rather than designing a complicated and elaborate design where people fail to maintain them.

2.3. Grounds Maintenance

Grounds maintenance consists of timely repairs and cleanup, the wise use of chemicals, continuous inspection, and a never ending attempt to uphold sharp and organized grounds. These attractively designed and well-maintained lawns, gardens, and flower beds create an overpowering positive first impression, ascertain a serene mood, and play an increasingly important role when it comes to property values. In order for a landscape to be practical and satisfying, grounds maintenance takes time, money, and an extreme amount of effort from laborers.[9]

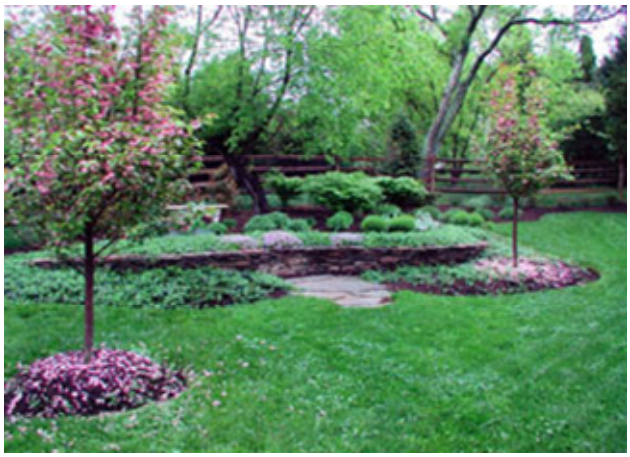

Figure 4: An example of Area 1

In order to have successful grounds maintenance, objectives must be understood and standards must be followed. Most of the time, objectives are very general, portraying ideas such as keeping the area clean and well groomed, while other objectives may be more specific depending on the area. Maintenance standards are made up of two areas, simply named Area 1 and Area 2. According to the Tennessee Valley Authority, Area 1 includes all grounds surrounding the major and auxiliary structures that are considered a part of the operating unit, and those areas in parks and other public lands where it is defined or developed specifically for use by the general public. This includes picnic areas, observation points, entrance triangles from highways, and major access roads to

[9] http://www.bls.gov/oco/ocos172.htm

the general developed area. Area 2 is defined as any area that includes all meadows, pastures, farms, and forest lands within the public ground property lines and all other areas not covered under Area 1.[10]

Grounds workers must understand which area they are working on in order to develop accurate objectives. It is quite obvious now that Area 1 requires much more attention and planning than Area 2. Area 2 is more natural; where as Area 1 is more manmade and structured.

Area 1 is the most common when it comes to grounds maintenance. Workers must pay close attention to all the little details that everyone takes for granted. They must be aware of roads and pathways, making sure they are smooth and drivable; lawns must be a large concern as well, and it has to be cut, trimmed, and groomed on a frequent basis. Trees, shrubs, and planting beds are also a major focus when it comes to grounds maintenance. In addition, workers have to worry about parks and picnic areas, which include the disposal of trash along with the customary planting and grooming. Even though Area 1 includes all these details, it still has the most backbreaking and time consuming activity and that is weeding, a large factor that can make or break a landscape.

Figure 5: An example of Area 2

Area 2 does not take as much work to take care of and

[10] Conover, Herbert S. Grounds Maintenance Handbook. 3rd ed. Vol. VIII. New York: McGraw-Hill, 1977.

maintain. The main goals are preventing forest fires and erosion. Every once in a while, dead or fallen trees must be removed and tall grasses that have risen up over a foot tall must be trimmed. Other than this inconsistent work, all the time, money, and labor usually gets put towards the maintenance of areas similar to those described in Area 1. [11]

The labor involved with grounds maintenance is both mentally and physically draining. The overall cutting, trimming, mowing, and planting involve demanding and repetitive lifting, bending and shoveling. Over time this work plays a major role in the causes of backache and other pains. As if the physical nature is not enough, mentally pressure is put on these workers to make everything perfect by a certain deadline. Whether it is graduation or a sporting event, grounds maintenance workers are fighting the clock almost everyday.

Grounds maintenance workers held about 1.3 million jobs in 2002. Employment was distributed as follows:

Grounds Maintenance Employment (2002)	
Landscaping and grounds keeping workers	1,074,000
First-line supervisors/managers of landscaping, lawn service, and grounds keeping workers	150,000
Tree trimmers and pruners	59,000
Pesticide handlers, sprayers, and applicators, vegetation	27,000

Approximately one-third of the workers in grounds maintenance were employed in companies providing landscaping services to buildings and dwellings. Others worked

[11] Ibid

for property management and real-estate development firms; lawns and garden equipment supply stores; and amusement and recreation facilities, such as golf courses and racetracks. Some were employed by local governments; installing and maintaining landscaping for parks, schools, hospitals, and other public facilities. Almost one out of every four grounds maintenance workers was self-employed, which means to provide landscape maintenance directly to customers on a contract basis.[12]

Grounds maintenance, for most entry level positions, usually has no minimum educational requirements. However, most states require a certification if pesticides are being used. The Professional Grounds Management Society (PGMS) offers certification to grounds managers who have had a combination of eight years of experience, a formal education beyond high school, and who have passed an examination covering subjects such as equipment management, personnel management, and environmental issues. Moreover, The Associated Landscape Contractors of America (ALCA) offers the designations "Certified Landscape Professional (Exterior and Interior)" and "Certified Landscape Technician (Exterior or Interior)" to those who meet the certain requirements.[13] Grounds maintenance workers may also have the opportunity to start their own business after several years in their profession.

The job market is always open for grounds maintenance workers, mostly because it usually does not pay extremely well and the work is highly demanding. More and more opportunities are continuing to grow due to the fact that society is expanding. Everywhere you look another building or housing facility is being built. With all the

[12] http://www.bls.gov/oco/ocos172.htm
[13] http://www.bls.gov/oco/ocos172.htm

growth that is occurring, the need for grounds maintenance workers is growing as well. In order for a new facility or complex to prosper, the grounds that surround it are playing a more important role in the overall value of the property.

2.4. Maintenance of Flowers/Plants

Plants and flowers are generally divided into two categories.

1) The first category is annuals. Annuals are plants that grow, flower, set seed, and die in the same season, usually from spring to fall. Annuals have the significant role of adding color to a landscape and are available in wide ranges of textures, shapes, and colors. They are easy to grow and relatively inexpensive plants. The disadvantage of annuals is that they must be purchased year after year and often require diligent deadheading and a mid-season cutting back to provide continuous bloom. Because of their continuous blooming, they also usually require supplemental water and fertilizer. Annuals are usually divided into three groups in accordance to the climate and maintenance required. The following information is directly quoted from the SISLA website:[14]

Hardy Annuals

- Grown primarily for spring blooming;
- May be late-season bloomers and bloom well in the cool, fall temperatures;
- May be sown directly into the soil as soon as it is workable;
- Germinate and thrive in cooler temperatures;
- Usually retreat or even die off in the summer heat;
- Many are self-sowing.

[14] http://www.sustland.umn.edu/

Half-hardy Annuals

- Should be sown indoors;
- Should be set out or planted when evening temperatures are 55° F and above;
- Will tolerate some cooler temperatures;
- Usually bloom well in late spring / early summer, fade during the heat of summer, and then may bloom again in early fall;
- Some are self-sowing.

Tender Annuals

- Have no tolerance for temperatures below 55° F, and prefer 70° F day and night;
- Bloom in the heat of summer (July - August);
- Require a longer growing season, so should be started indoors and moved outside only when all danger of frost has passed;
- Very few self-sow.

2) The second type of flowers is Perennials. Perennials are plants and flowers that grow year after year. Trees and shrubs, for example, are perennials. The advantage of growing perennials is that they do not need to be planted and taken out every year. In addition, with careful preparation, a perennial flower bed will change colors as one type of plant finishes and another variety begins to bloom. Perennials require pruning and maintenance to keep them attractive. Their relatively short bloom period counts for a disadvantage, but by combining them with annuals, a continuous colorful show can be provided.

Figure 6: Campus Center at WPI

After planting any type of flower/plant, a lot of maintenance is required to help nourish the plant so it will grow correctly. Mulching the flower bed helps conserve soil moisture, retard weeds growth, and moderate soil temperatures. There are many different types of materials used for mulch. Some examples of mulch are gravel, stones, bark, dry grass chipping, and other hulls of various sorts. When mulching around the flowers, an air space should always be left on the mulch and at the crown of the plant so as to avoid problems with crown rots. Mulching also helps to cut down watering frequency.

Watering is the most essential part of planting any flower or plant. Different flowers require various watering schedule. But in general, drenching the flower directly

after planting it and then check regularly will prevent it from drying out. The general rule of thumb that one inch of water per week for established plantings holds true.[15]

[15] http://www.urbanext.uiuc.edu/perennials/

2.5. Landscape Design and Ground Maintenance at WPI

We must gather information on the amount of employees involved in Plant Services, along with their hours of work; including their time spent with the flowers. We should know this in order to develop of plan of maintenance for the planting beds. We also have to take into consideration the amount of money Plant Services has to spend on flowers and plants at WPI. Additionally, funding and resources must also be accounted for.

2.5.1. Flower Bed Design at WPI

At Worcester Polytechnic Institute, the main premise for landscape design on campus appears to follow the "simple yet effective" method. By "simple", we mean that there are not rare, strange, or unusual species of plants found on campus. In fact, the core of the campus is the common Rhododendron. By taking a tour of the campus almost in any direction, one will run into these plants. The "effective" part of the motto is a little more difficult. It derives from the ability to use basic landscape design principles without going overboard. For instance, by taking certain types plants and then grouping them together in a bed or by lining them against a backdrop or a wall. With the right amount of plants and combinations of areas, the possibilities seem endless, yet only the right combination will work to catch the eye.

On Campus, the seven main species of plants and flowers you will find are included as follows: Astilbe, Daylily, Azalea, Black-eyed Susan, Bayberry, Hosta, and the Rhododendrons. Note that these are all perennials. During the spring and especially for commencement, the Plant Services team brings in New Guinea Impatiens to add hints of color to the campus. It is these eight plants that make up the planting beds, along with

other items such as trees and larger bushes known as Yews, Taxus baccata. The types of beds on campus vary based on location and their level of maintenance. The Campus Center beds and the beds which are not against a building are designed by using a combination of techniques. The spacing for the perennials follows an evenly spaced triangle pattern which typically follows a line through most of the beds. Once the time is right, Plant Services will begin to plant their annuals around the outsides of the bed, which enhances the border.

As the planting beds progress towards the sides of the buildings, we begin to notice a different strategy. The larger, more dominate plants can be seen at the back of the beds which are pressed against the buildings, while the smaller of the plants are spread evenly in front. This allows the onlooker to see a gradient of color sloped towards the lecture halls. For example, on the side of Alden closest to West St. you will notice this pattern. Against the building are the large and older Rhododendrons and in front of them are the smaller Azaleas, but then in front of the Azaleas are the Daylilies.

As previously mentioned, perennials and other plants look best when they are planted together in groups and even better when they are planted together in a bold, colorful set. Then having something solid in the background such as a building or a wall will allow onlookers to focus their attention directly on the plants and colors rather than other elements of the environment. One example of this which has earlier been referred to as the "core" of the campus is the Rhododendron. The Rhododendrons on campus are never found alone, and when they are grouped in even larger groups, like they currently are, the spring belongs to them. Once they bloom on campus, it seems as if the whole place is in bloom. Another example of this can be found at the front of both the Alumni

Gym and the Campus Center. There are two beds of daylilies planted on each side of the entrances. This works for both because, even though the daylilies at Alumni are planted in high planters, they are grouped together to make a string of color. And while there are more daylilies planted in front of Alumni, the Campus Center daylilies work evenly as well because they are planted with the granite walls directly behind them.

2.5.2. Flower Bed Maintenance at WPI

Here at WPI, the planting beds need constant maintenance in order to maintain their healthy and beautiful status. Planting beds usually fall into two categories when being considered for maintenance.

Figure 7: WPI Main Entrance Sign

Either the planting bed needs continuous maintenance or it does not. The planting beds that can not survive without care are tagged with a Level 1 maintenance label, the level that requires the most care. If the planting bed does not need regular upholding, then that bed is given a Level 2 maintenance label.

These maintenance levels coincide with the standard maintenance areas, Area 1 and Area 2. A planting bed with the characteristics of Area 1 would receive a Level 1 maintenance label. Whereas a planting bed that resembled the distinctiveness of Area 2 would be considered a Level 2 maintenance level. This allows us to better prioritize our grounds for maintenance.

Another consideration we must focus on is the campus tour route. This is the route where prospective students are walked when taking a tour of WPI. This path must always be maintained to the best of Plant Services' ability. We want the future students to feel comfortable and enjoy the sights that make up our beautiful campus. The path should also look nice and well-maintained because as a school we are selling ourselves to these students. We want to be able to be proud of what we have and be able to show it to our visitors. Therefore, along with focusing on Level 1 planting beds, the campus tour route should also be high on the maintenance priority list.

3. Methodology

The goal of this project is to help the Plant Services team at WPI create an effective way of maintaining and preserving the campus's planting beds by developing a computerized way to plan and coordinate all of these services. The idea is to gather this information and plot out each bed, revealing the plants, their properties, and the tasks and costs for maintaining them. After analyzing the information, we will strive to produce a successful plan for a continuously beautiful campus that is filled with color throughout the year at WPI.

We have indicated three major objectives that we will focus on in order to complete our project. The objectives are as follows:

I. **Inventorying information about each planting bed**
II. **Quantifying the maintenance needs for the planting beds**
III. **Developing a cost-effective, priority-based maintenance plan**

We are dealing with plants, flowers, sun, shade, mulch, stone, and irrigation. All other aspects of landscaping, such as lawns and trees, are unaffiliated with this IQP project due to the fact that this project strictly focuses on the planting beds. The area of study that we have focused on is located on the WPI campus which we have mapped out. Ideally, this project will cover the entire campus, focusing mainly on the route most commonly used for campus tours, the quad, the campus center, and down the hill towards West Street.

Our On-Campus project began in September 2005 and will be completed by the end of May 2006. However, due to the different seasons and the dramatic shifts in weather, our objectives have been accelerated. Most of our research, along with all of our data collection, will need to be completed before the snow sets in. This will provide sufficient time during the winter and spring months to produce results and further analyze them in order to fulfill our second and third objectives.

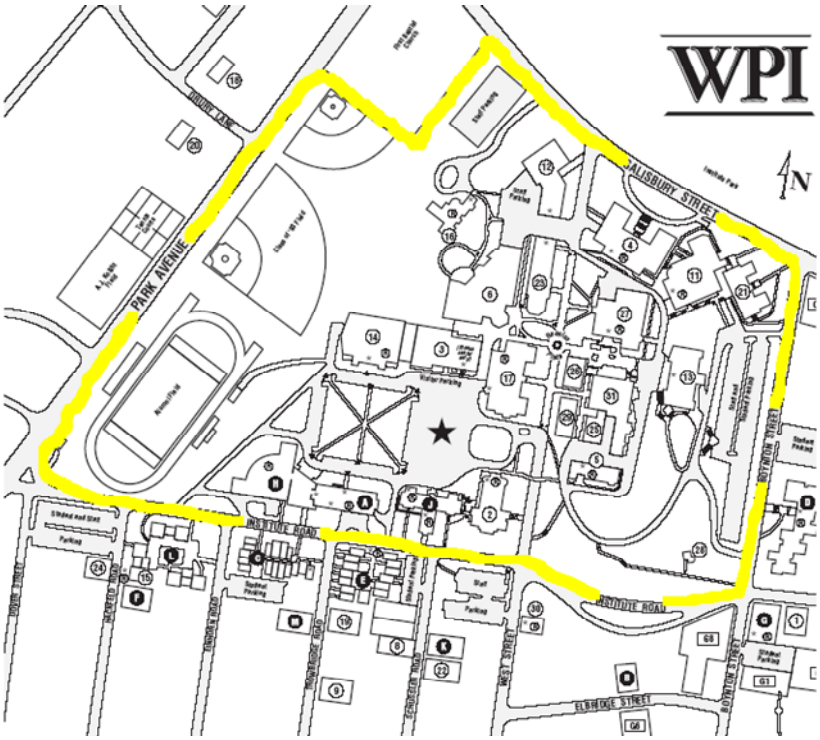

Figure 8: WPI Campus Map

3.1. Inventorying information about each planting bed

While beginning our research for this project, we came across many new and useful tools that we took full advantage of. The primary tool we mastered was Map Info. This computerized mapping system enabled us to display a better visual of the area of campus that our project is focused on. By situating an orthophoto on top of a map of campus, understanding our isolated area of study was much simpler. The boundaries of our project were marked by the area between four main streets which included Institute Road, Park Avenue, Salisbury Street, and Boynton Street.

Figure 9: Orthophoto of WPI

Once we had identified the area in which we were going to work, we had to create a method of collecting data. We went to the campus and closely examined one flower bed. We took notes on what we felt needed to be considered when taking an inventory of

E-Grounds-06

Island #	Bed #	Picture #	Date

Grass	Mulch	Dirt	Stone
%	%	%	%

Shade/Sunlight	Shaded	Partially Shaded	Direct Sunlight

Accessibility	Easy	Moderate	Difficult
Foot:			
Truck:			

Flowers/Plant name:	Number planted	Annual	Perennial	Single	Bunch	Row
1)						
2)						
3)						
4)						
5)						
6)						
7)						
8)						

Other Notes

Figure 10: Example of Data Collection Chart

a planting bed. With this information roughly written down, our next step was to contact Ron Klocek, the Grounds & Properties Manager. We showed Ron the information we collected and asked of his opinion. He agreed with most of our plans, but added more to what he felt was necessary. After making many revisions, we took all the information we

had from previous attempts at our data chart and designed a data chart that worked well when inventorying the planting beds. This chart assured us that we would not forget anything.

Along with this data collection chart, we also needed a corresponding map of the island that surrounded the bed. We were able to print out maps of each island using Map Info. This enabled us to correctly map out the dimensions of the planting bed. Using the map, we could also plot the individual flowers and plants, creating a database that was very practical.

To isolate the specific planting beds to coordinate with our maps before jumping into our study areas, we had to carefully plan out which planting beds will get examined

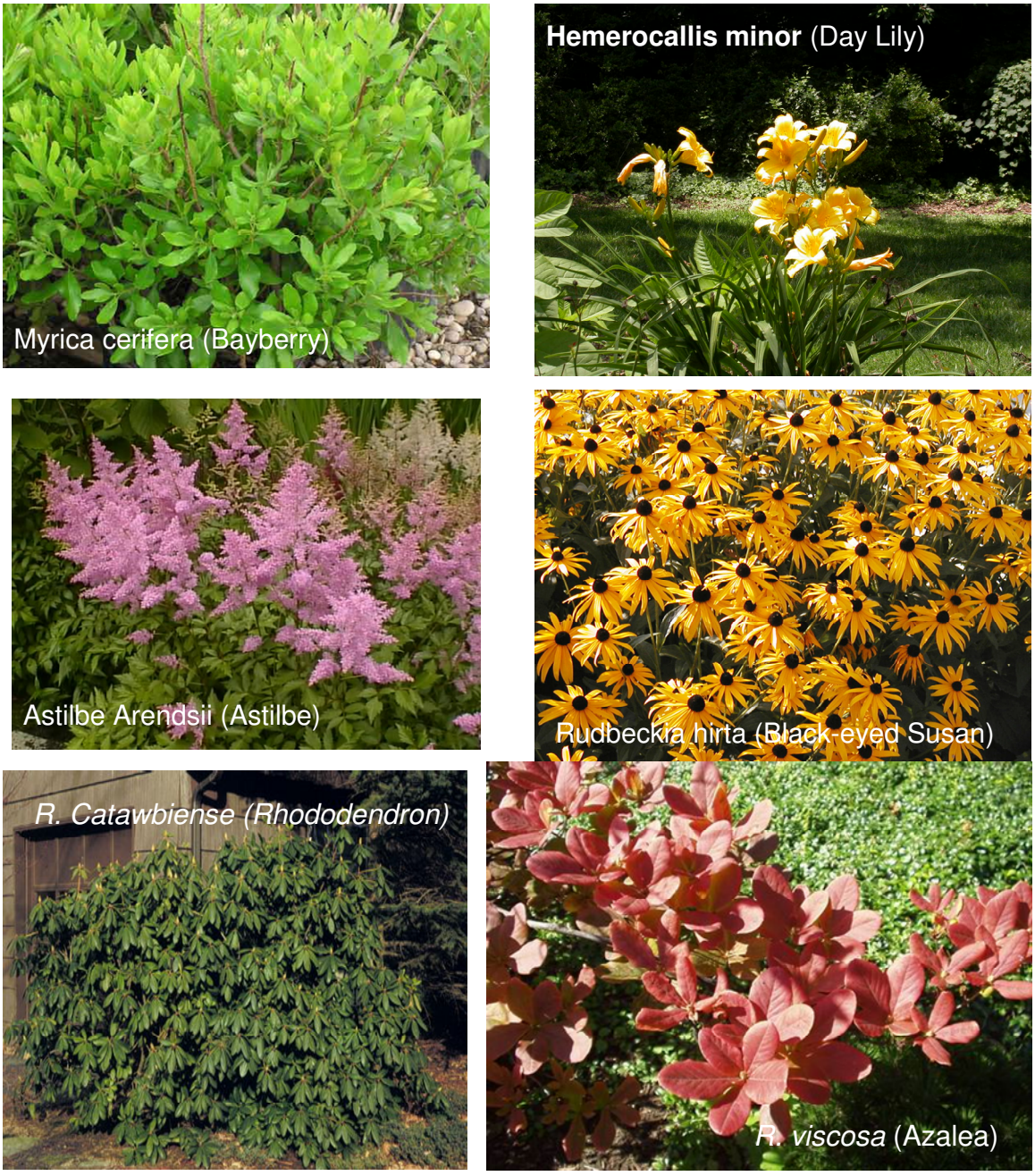

Figure 11: Example of Plants

and by whom. We decided to split up the planting beds by the buildings in which they surrounded. Each bed has been given a letter code according to the initials of the

corresponding building. Then the beds individually got their own number along with the buildings initials. This code was then transferred from the maps to the data collection charts.

We each took approximately one-third of the campus and the buildings in that section. With a precise plan of where to begin, we were officially ready to start our data collection.

With the data charts and maps ready to be tested in our field of study, we gathered everything we needed before heading out. The supplies included writing utensils, a digital camera, a tape measure, the data charts, and our maps.

Gathering the information consisted of properly identifying the plants and flowers, which due to our background research was quite simple. Anytime a flower or plant was unidentifiable, we were able take a picture of the individual item to show it to Ron. Sometimes even a simple vocal description was all that was needed to identify it. The WPI campus is made up of six major plants and flowers; these included the Yew, the Day Lily, Astilbe, the Black-eyed Susan, the Azalea, and the Rhododendron. These perennials made up a majority of the campus; however they are not the only ones. Some other plants and flowers included many types of ground covering plants, Burning Bushes, and other species of Azaleas and Rhododendrons.

With the information we have gathered, we then entered it into our data charts and plotted out the dimensions of the bed and the plants' location on our maps. An example of one data chart and its corresponding planting bed can be seen as follows:

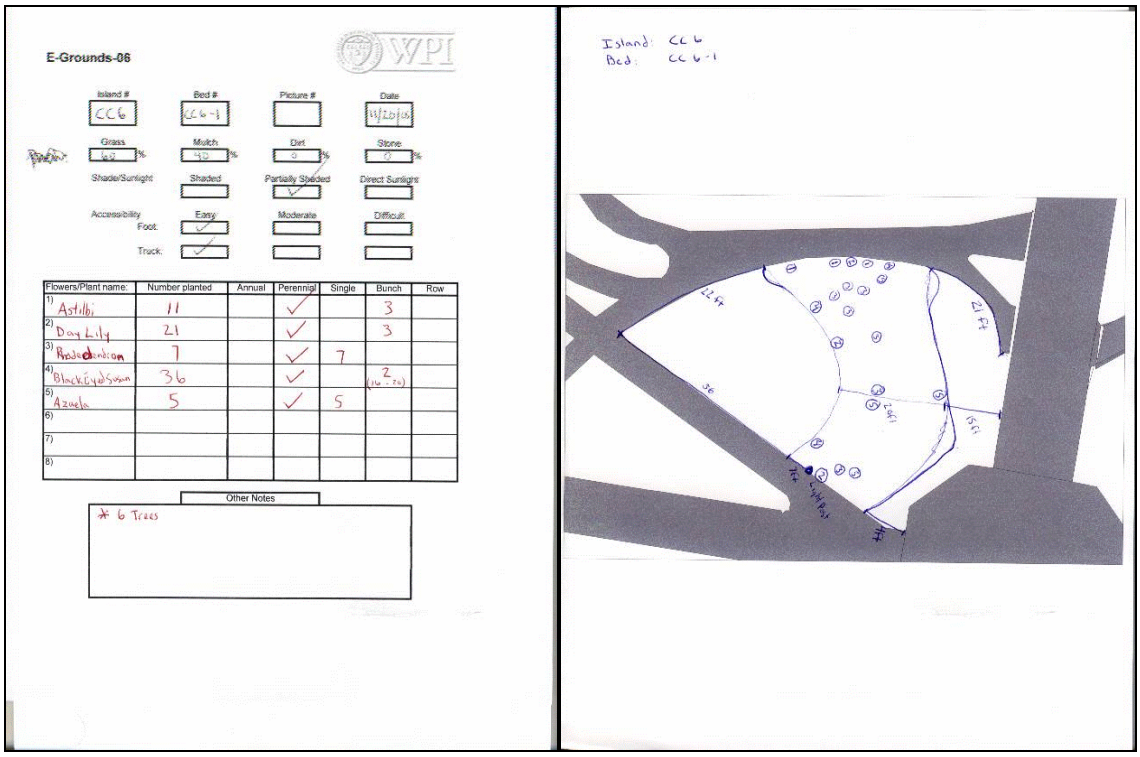

Figure 12: Data Collection Example

This method of collecting data worked very well and therefore we continued to use it on each and every planting bed in our designated area of study. For each bed we produced a similar chart with its corresponding map. This completed our first objective as the inventory of each planting bed was carefully gathered and precisely recorded.

Now that all of our data is collected, we were able to replicate it on the computer using the Map Info program. In order to do this, a layer was created in Map Info that consisted of the planting beds. Separate layers were also generated for the islands and the individual plants and flowers. These different layers of maps eventually became the results of our data collection.

3.2. Quantifying the maintenance needs for the planting beds

We wanted to be able to apply the knowledge that we have about the care for different plants and flowers. Ideally we wanted to add this information to the planting beds' database, making it simple for the care of the bed to be known and understood by all. Whether the bed needs irrigation or constant weeding, we added this information to the planting beds' database, which will then enable us to create a maintenance plan that can be easily followed in order to better preserve the campus of WPI.

Our plan of maintenance would not work if we do not have the funds in order to achieve our goal. Therefore, we had to do research with the help of the Plant Services Department in order to better understand our financial limitations. Once we were given the total that was used for the maintenance of the planting beds, we were able to better assess our maintenance plan. Our plan began by calculating the cost of each planting bed. Since we knew the square footage of the bed, we were able to calculate the price of mulch by the amount needed to cover the bed. We will also found the price of each flower or plant and the number of them in each planting bed, giving us a total price of plants and flowers per each planting bed. With the annual value and total value of each bed being calculated, we were then able to determine how much money will be left over in order to be put towards other aspects of the planting beds. This also has allowed us to visualize the monetary value of the bed, and because the aesthetic value of a bed is directly proportional to cost, we will now be able to increase or decrease the values where we felt it was necessary.

Another aspect that we focused on was labor. If there was money left over, we could determine if it would be beneficial to pay some laborers more in order for them to

spend more hours concentrating on the planting beds. However, now we had to take into consideration the total number of hours that each Plant Services' worker put into the planting beds each week. Also, we had to determine if the time spent with the planting beds is time well spent or if it is wasted time due to the lack of a strict maintenance plan.

3.3. Developing a cost-effective, priority-based maintenance plan

3.3.1. Priority Levels

When determining priority levels, we needed to recognize which planting beds on the WPI Campus are the most important. We took into perspective possible incoming students, current students, and faculty. What we did was target the high traffic areas of WPI. These areas included the Campus Tour Route, the Campus section of West Street, the intersecting paths of the fountain, and all of the entrances to WPI. A lot of the main buildings that should be of high priority are located along the Campus Tour Route, such as the Campus Center, Morgan Dining Hall, and Gordon Library. The beds along these paths would all be given a high priority level. Other paths and areas around WPI that are commonly used would be given a medium priority level with their respected beds, while beds that are hidden away and not often seen would be given a low priority rating.

In order to tag each planting bed with a specific priority level, we created a buffer system throughout those high traffic paths that we picked out. Any beds within the buffer zone would receive a 10 label, displaying a high priority level. The beds that are outside of this buffer but still within 30 feet of the zone received an 8 label, displaying a medium priority level. Finally, the beds that are not within either zone or tucked away out of sight received a 5 label, displaying a low priority. Any beds that do not need care or are not contracted to WPI Plant Services received a 0 label. The map pictured below in Figure 13 is a Priority Level map with the corresponding priority numbers.

Figure 13: Priority Numbers map

To better visualize where our priority levels came from, we also have a map that displays the buffer zone that we previously talked about. The buffer zone depicts where the high priority beds should be. The medium priority beds should be outside of this zone, along with the low priority beds, the ones that do not need much attention due to the fact that they are located in places that are not as easy to see as the beds in the other two levels. Below, in Figure 14, is a map of the Priority Buffer Zone map.

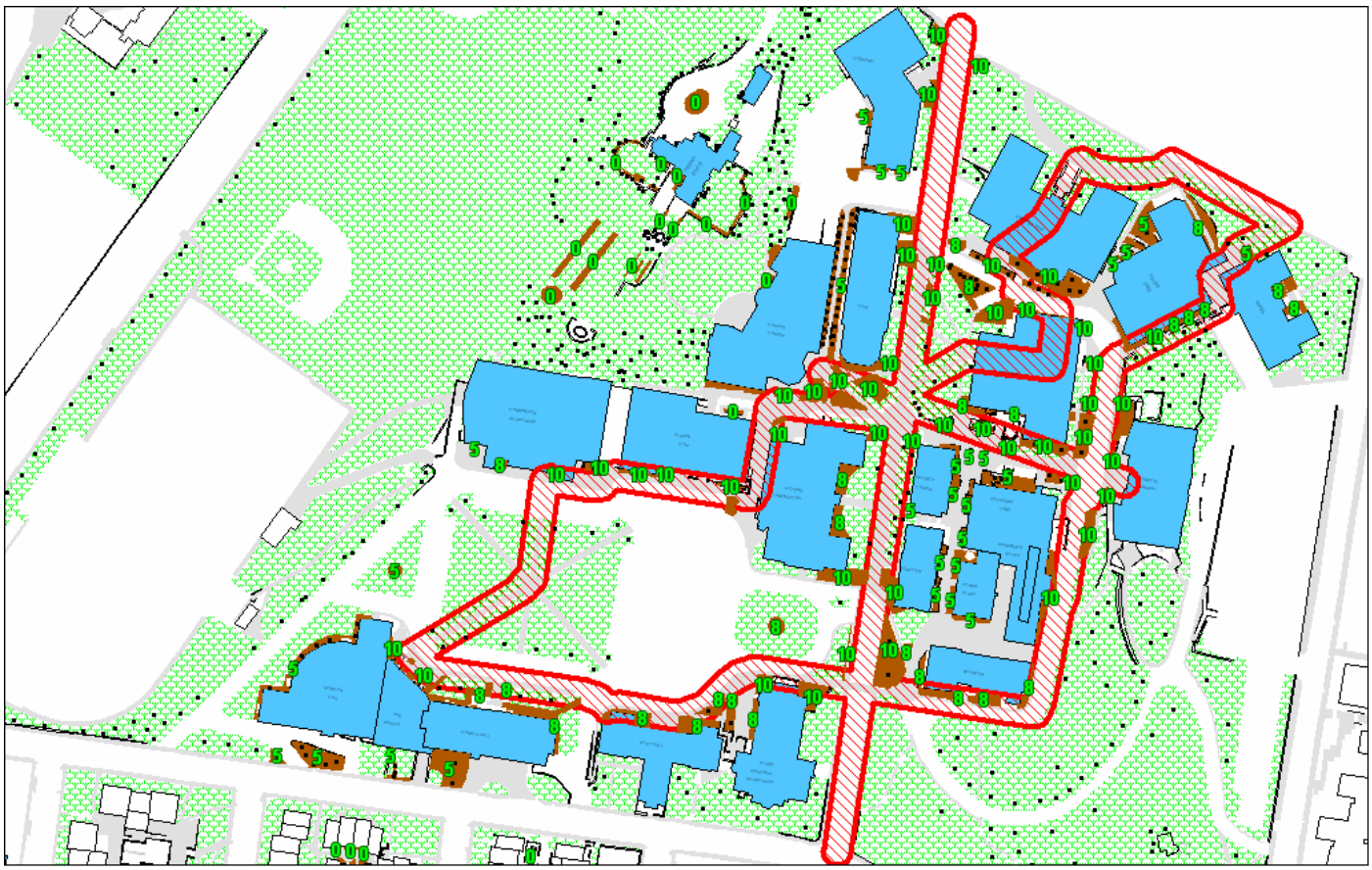

Figure 14: Priority Buffer Zone map

3.3.2. Cost Matrix

The first element of our cost efficiency mechanism was to create a cost matrix. We created this cost matrix using Microsoft Excel, making it simple to understand and user friendly. We wanted a program that would calculate the total cost of a planting bed here on campus, as well as the maintenance cost, and the annual total cost. By producing such a program, we would be able to identify the total value of a planting bed. With this information, it would be simple to determine which beds are more expensive and need more time spent on them. By using this cost matrix along with certain priority levels, we would easily be able to establish which beds should have their value increased or

decreased in order to maximize the cost efficiency of the planting beds throughout the WPI campus. Plant Services would then be able to recognize which planting beds or areas of campus should get the most attention and time spent on them in order to put together the best looking campus possible.

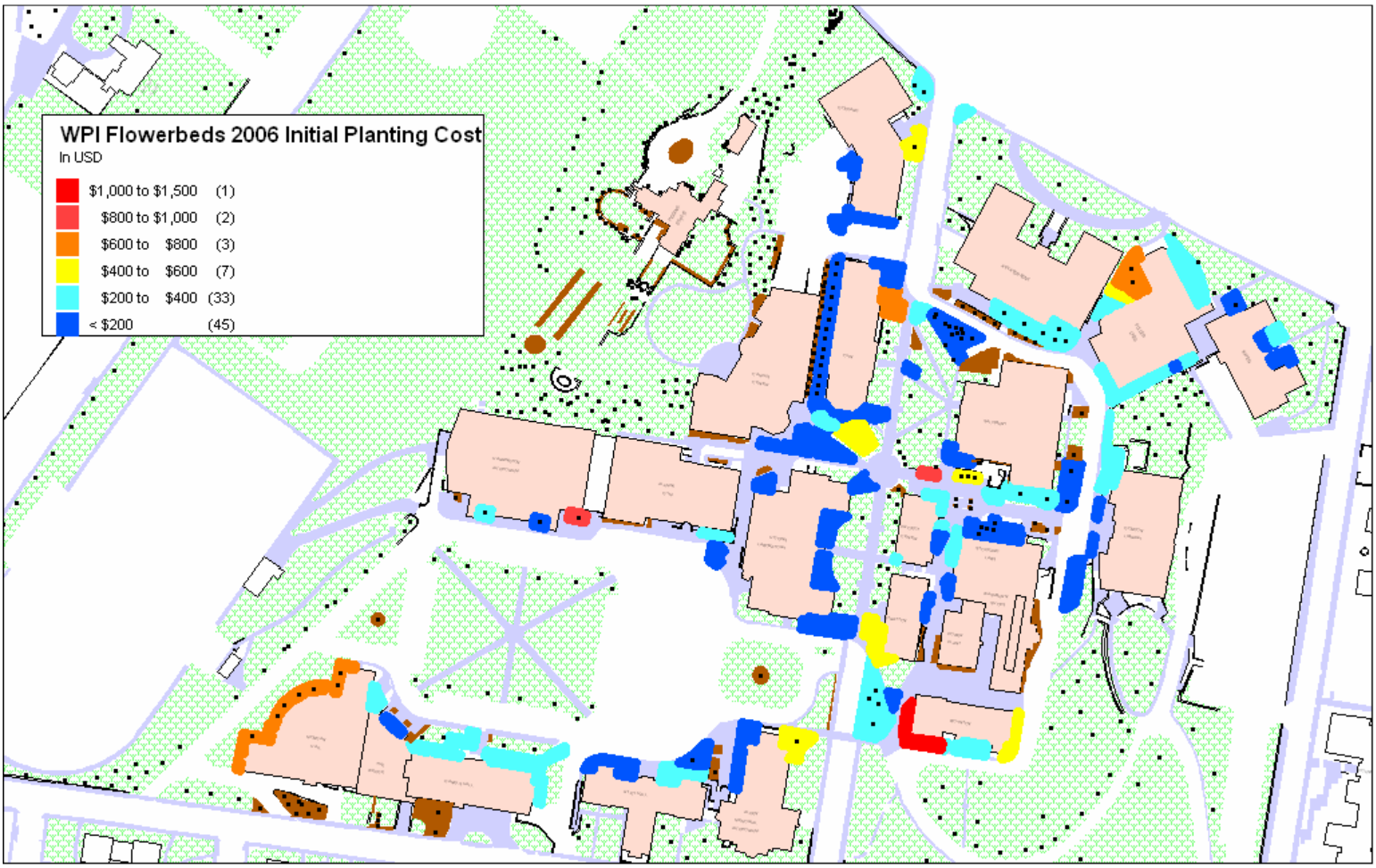

Figure 15: Initial Planting Cost map

The initial planting cost per bed is made up of the plants' unit cost plus the labor time to put the plant in. We were given the average hourly wage per worker, which was $16.55. We took this wage and multiplied it by the time it took in minutes to execute the planting. This result was then added to the unit cost of the plant, and then multiplied by

the total number of the plants. This was done for each different plant in the planting bed to give us the Initial Planting Cost per bed, which is shown above in Figure 15. The unit

Flower	Unit Cost	Labor Hours
Astilbe	$10.00	0.17
Azalea	$65.00	0.34
Black Eyed Susan	$10.00	0.17
Day Lily	$8.00	0.17
Rhododendrons	$50.00	1.00
Yew	$50.00	1.00
Ground Covering	$6.00	0.50
Burning Bush	$75.00	1.00

Figure 16: Plant Unit Cost Table

costs for each plant along with the time needed to plant each are located in Figure 16.

4. Results

4.1. Introduction

Our initial design towards calculating our results began with the creation of a Cost Matrix. A major concept that we wanted to analyze was the cost of our planting beds and the amount of money that it takes to create and maintain them. Ideally we wanted to be able to tie both of these concepts together. With the assistance of John Miller and Ron Klocek, we determined that a Planting Bed Cost Matrix would be a principle tool to assist us with the evaluation of our planting beds.

Some factors that we have chosen to include are described as follows:

- **Unit Cost:** Value of Each plant.
- **Unit Labor:** Total Payroll is $32,704.56/52 = $628.93/40 = approx $15.50 per Hour
- **Time to do:** Approximated the time it would take to complete the work in minutes over one hour.
- **Cost:** Unit Cost + (Unit Labor * Time to do)
- **Cost for Maintenance:** (Unit Labor*Time to do)*Sqft/1000
- **Total Value:** (Cost * Number of Plants)
- **Total Maintenance Cost:** (Cost * Number of Times per Year)
- **Total Cost Per Year:** [(Total Value * 1/5) + Total Maintenance Cost]

With this information, we then developed a matrix through Microsoft Excel that completed these calculations as well as allowing the user to simply add, delete, or modify the information.

As you can see from Figure 17 we calculated the total value of the bed, the total

Flower Bed:	CC6-1	Sqft:	780			
	Unit Cost	Hourly Wage	Labor Hours	Cost	# of Plants	Total Value
Flower						
Astillbe	$10.00	$15.50	0.17	$12.59	11.00	$138.47
Azalea	$50.00	$15.50	0.34	$55.27	5.00	$276.35
Black Eyed Susans	$10.00	$15.50	0.17	$12.64	36.00	$454.86
Day Lily	$8.00	$15.50	0.20	$11.10	21.00	$233.10
Rhododendrons	$50.00	$15.50	0.50	$57.75	7.00	$404.25
Shrub						
Yew	$50.00	$15.50	0.50	$57.75	0.00	$0.00
Ground Covering	$6.00	$15.50	0.50	$13.75	0.00	$0.00
Burning Bush	$75.00	$15.50	0.50	$82.75	0.00	$0.00
				Total Value of Flower Bed		$1,507.03
				Total Plants	80.00	
Mulch	$21.95	$15.50	0.39	$111.73	1.00	$111.73
Watering		$15.50				$0.00
Fertilizing	$15.00	$15.50	1.33	$21.84	2.00	$43.67
Weeding		$15.50	0.50	$6.05	2	$12.09
Edging		$15.50	0.50	$6.05	2	$12.09
Deadheading		$15.50	0.50	$6.05	2	$12.09
Pruning		$15.50	0.50	$6.05	2	$12.09
				Total Maintenance Cost		$203.76
				Total Cost Per Year		$505.17
Total Payroll	$32,704.56					
Payroll Per Week	$628.93					
Payroll Per Hour	$15.72					

Figure 17: Excel Sheet Example

maintenance cost, and the total cost per year. By determining the value of each planting bed, we established how much each bed costs. We then were able to focus on the desirability and/or location of the bed to increase or decrease the value. This has enabled us to create the best looking campus possible that our budget will allow.

Our idea of a Cost Matrix seemed flawless at first; however, once we wanted to link this information with Map Info, a few problems arose. For one, Microsoft Excel and Map Info are not compatible. Also, using Excel added a few extra steps that should not be

necessary. We would have had to enter the data into Excel which produced a result. We would then have to enter this result into a new table and database in Microsoft Access. With this information in Access, we would then have to link it to Map Info in order to produce a map, which is the final result we want. This is confusing and is the reason why we chose to do away with the Excel version of our Cost Matrix.

A simple solution to our problem was to work primarily with Microsoft Access. We had to re-create our Cost Matrix in Access which was tricky, but produced the results that we wanted. We were able to enter all of our information into this one program, which directly linked with Map Info, eliminating all of the steps in between that we would have had to deal with if we stayed with Excel.

4.2. Bed Inventory Databases

When working with the program Map Info, the most effective program to work alongside it is Microsoft Access. Our data in Access directly links the planting beds and their individual landscape properties to and from Map Info. Using Access Databases, we have taken our original recorded data and separated it into two databases. The first is a database reflecting individual "Islands." The recorded fields of data include the following: Island ID #, Bed ID #, percentages of mulch, dirt, grass, and stone, amount of sunlight, foot accessibility, and truck accessibility. Figure 18 shows a direct example of the Island Database.

Island_ID	Bed_ID	Date	Grass %	Mulch %	Dirt %	Stone %	Amount of Sunlight	Foot Accessibility	Truck Accessibility
GL-FB-3	GL-FB-3-1	12/1/2005	0	100	0	0	Partially Shaded	Easy	Easy
GL-FB-4	GL-FB-4-1	12/1/2005	0	50	50	0	Partially Shaded	Easy	Easy
GL-FB-5	GL-FB-5-1	12/1/2005	0	100	0	0	Partially Shaded	Easy	Difficult
GL-FB-5	GL-FB-5-2	12/1/2005	0	100	0	0	Partially Shaded	Easy	Difficult
HA-FB-1	HA-FB-1-1	1/25/2006	0	99	1	0	Direct	Easy	Easy
HA-FB-2	HA-FB-2-1	1/25/2006	0	99	1	0	Direct	Easy	Easy
HA-FB-3	HA-FB-3-1	1/25/2006	0	99	1	0	Direct	Easy	Easy
HA-FB-4	HA-FB-4-1	1/25/2006	0	99	1	0	Direct	Easy	Easy
HA-FB-5	HA-FB-5-1	1/25/2006	0	99	1	0	Partially Shaded	Easy	Moderate
HA-FB-6	HA-FB-6-1	1/25/2006	100	0	0	0	Partially Shaded	Easy	Moderate
HL-FB-1	HL-FB-1-1	1/25/2006	0	50	50	0	Partially Shaded	Easy	Easy
HL-FB-2	HL-FB-2-1	1/25/2006	0	20	80	0	Partially Shaded	Easy	Easy
HL-FB-3	HL-FB-3-1	1/25/2006	0	20	80	0	Partially Shaded	Easy	Easy
HL-FB-4	HL-FB-4-1	1/25/2006	0	99	1	0	Partially Shaded	Easy	Easy
MH-FB-1	MH-FB-1-1	1/25/2006	0	99	1	0	Partially Shaded	Moderate	Easy
MH-FB-2	MH-FB-2-1	1/25/2006	0	99	1	0	Partially Shaded	Easy	Easy
MH-FB-3	MH-FB-3-1	1/25/2006	0	99	1	0	Partially Shaded	Easy	Easy
MH-FB-4	MH-FB-4-1	1/25/2006	0	99	1	0	Partially Shaded	Easy	Easy
MH-FB-5	MH-FB-5-1	1/25/2006	0	99	1	0	Partially Shaded	Easy	Easy
MH-FB-6	MH-FB-6-1	1/25/2006	0	99	1	0	Partially Shaded	Easy	Easy
MH-FB-7	MH-FB-7-1	1/25/2006	0	99	1	0	Partially Shaded	Easy	Easy
MH-FB-8	MH-FB-8-1	1/25/2006	0	99	1	0	Partially Shaded	Easy	Easy
OH-FB-1	OH-FB-1-1	11/29/2005	60	40	0	0	Partially Shaded	Easy	Moderate
OH-FB-1	OH-FB-1-2	11/29/2005	0	100	0	0	Partially Shaded	Easy	Moderate
OH-FB-2	OH-FB-2-1	11/29/2005	0	100	0	0	Partially Shaded	Easy	Easy
OH-FB-2	OH-FB-2-2	11/29/2005	90	10	0	0	Partially Shaded	Easy	Easy
OH-FB-3	OH-FB-3-1	11/29/2005	60	20	20	0	Partially Shaded	Easy	Easy
OH-FB-3	OH-FB-3-2	11/29/2005	60	20	20	0	Partially Shaded	Easy	Easy
OH-FB-3	OH-FB-3-3	11/29/2005	60	20	20	0	Partially Shaded	Easy	Easy
OH-FB-4	OH-FB-4-1	11/29/2005	0	100	0	0	Partially Shaded	Easy	Easy
RH-FB-1	RH-FB-1-1	1/25/2006	0	50	50	0	Partially Shaded	Easy	Easy
RH-FB-2	RH-FB-2-1	1/25/2006	0	50	50	0	Partially Shaded	Easy	Easy
RH-FB-3	RH-FB-3-1	1/25/2006	0	50	50	0	Partially Shaded	Easy	Easy

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Figure 18: Example of Island Database

For the second database, we categorized all of our inventoried information about the planting bed. The fields for this database include the following: Plant ID, Common

Flowers/Plants Inventory : Table

Plant ID	Common Name	Genus	Species	Island #	Bed #	Total # of Flowers/Plants	Single	Bunch	Row
2	Daylily	Hemerocallis	minor	L5	L5-2	3	3	0	0
R	Rhododendron	Rhododendron	catawbiense	MO1	MO1-1	4			
Al	Azalea	Rhododendron	viscosa	MO6	MO6-1	1			
Al	Azalea	Rhododendron	viscosa	MO7	MO7-1	1			
R	Rhododendron	Rhododendron	catawbiense	MO8	MO8-1	1			
1	Azaela	Rhododendron	viscosa	OL1	OL1-1	1	1	0	0
2	Rhododendron	Rhododendron	catawbiense	OL1	OL1-1	3	3	0	0
3	Daylily	Hemerocallis	minor	OL1	OL1-1	4	0	1	0
2	Rhododendron	Rhododendron	catawbiense	OL1	OL1-2	5	5	0	0
1	Rhododendron	Rhododendron	catawbiense	OL2	OL2-1	1	1	0	0
2	Azaela	Rhododendron	viscosa	OL2	OL2-1	11	1	0	0
3	Black Eyed Susan	Rudbeckia	hirta	OL2	OL2-1	12	0	1	0
4	Daylily	Hemerocallis	minor	OL2	OL2-1	25	0	3	0
5	Astilbe	Astilbe	arendsii	OL2	OL2-1	11	0	2	0
2	Azaela	Rhododendron	viscosa	OL2	OL2-2	7	0	1	0
2	Azaela	Rhododendron	viscosa	OL3	OL3-1	6	0	1	0
4	Daylily	Hemerocallis	minor	OL3	OL3-1	5	0	1	0
3	Rhododendron	Rhododendron	catawbiense	OL3	OL3-2	3	0	1	0
1	Rhododendron	Rhododendron	catawbiense	OL3	OL3-3	3	0	1	0
2	Black Eyed Susan	Rudbeckia	hirta	OL3	OL3-3	14	0	0	1

Figure 19: Example of Flower Database

Name, Genus and Species, Island #, Bed #, the total number of each specific plant, and their orientation, as shown above, in Figure 19. The Island # and Bed # directly correlate to the prior database. The orientation as seen in Figure 19 refers to whether or not the plant is planted in a bunch with others, if it is planted in a row of plants, or if it is an individual plant.

4.3. Planting and Maintenance Cost Database

After we decided to leave our Excel Matrix behind, we then had to enter all of that data into Access. This comprised of re-creating all of the calculations that were done in Excel, in order to correctly get the final values we wanted. Several different tables and queries had to be made sequentially so that we could produce results such as the total number of flowers per bed, the initial planting cost per bed, the annual planting cost per bed, the yearly plant maintenance cost per bed, and the total annual planting cost per bed. All of these factors can be found in one database that also includes and corresponds with each individual Plant, Island, and Bed ID. An example of the database is pictured in Figure 20.

MAPINFO	Plant_ID	Island_ID	Bed_ID	Tot_No__Flowers	Initial_planting_cost	Annualized_Planting_Cost	Yearly_Maintenance_Cost	Total_Annual_cost
1	As	CC-FB-10	CC-FB-10-1	10	$465.85	$25.52	$0.00	$25.52
2	DL	CC-FB-10	CC-FB-10-1	21	$465.85	$45.19	$57.93	$103.11
3	R	CC-FB-10	CC-FB-10-1	7	$465.85	$93.17	$77.23	$170.40
4	BES	CC-FB-10	CC-FB-10-1	36	$465.85	$91.86	$99.30	$191.16
5	AI	CC-FB-10	CC-FB-10-1	5	$465.85	$55.52	$13.79	$69.31
6	DL	HL-FB-1	HA-FB-1-1	14	$150.62	$30.12	$38.62	$68.74
7	DL	HA-FB-7	HA-FB-7-1	28	$301.23	$60.25	$77.23	$137.48
8	R	HL-FB-2	HL-FB-2-1	1	$25.52	$13.31	$11.03	$24.34
9	R	MH-FB-11	MH-FB-11-1	4	$266.20	$53.24	$44.13	$97.37
10	AI	MH-FB-6	MH-FB-6-1	1	$55.52	$11.10	$2.76	$13.86
11	AI	MH-FB-9	MH-FB-9-1	1	$55.52	$11.10	$2.76	$13.86
12	R	MH-FB-7	MH-FB-7-1	1	$66.55	$13.31	$11.03	$24.34
13	R	DH-FB-3	DH-FB-3-1	5	$332.75	$66.55	$55.17	$121.72
14	R	DH-FB-5	DH-FB-5-1	13	$222.07	$173.03	$143.43	$316.46
15	AI	DH-FB-5	DH-FB-5-1	4	$222.07	$44.41	$11.03	$55.45
16	BB	DH-FB-5	DH-FB-5-1	1	$222.07	$18.31	$5.52	$23.83
17	AI	RH-FB-1	RH-FB-1-1	4	$107.58	$44.41	$11.03	$55.45
18	DL	RH-FB-1	RH-FB-1-2	10	$107.58	$21.52	$27.58	$49.10
19	AI	RH-FB-1	RH-FB-1-2	1	$107.58	$11.10	$2.76	$13.86
20	R	RH-FB-1	RH-FB-1-2	2	$107.58	$26.62	$22.07	$48.69
21	DL	RH-FB-2	RH-FB-2-1	16	$399.30	$34.43	$44.13	$78.56
22	R	RH-FB-2	RH-FB-2-1	6	$399.30	$79.86	$66.20	$146.06
23	AI	RH-FB-2	RH-FB-2-1	3	$399.30	$33.31	$8.28	$41.59
24	DL	RH-FB-3	RH-FB-3-1	5	$66.55	$10.76	$13.79	$24.55
25	R	RH-FB-3	RH-FB-3-1	1	$66.55	$13.31	$11.03	$24.34
26	H	RH-FB-3	RH-FB-3-1	1	$66.55	$4.55	$0.00	$4.55
27	R	RH-FB-4	RH-FB-4-1	1	$22.76	$13.31	$11.03	$24.34
28	H	RH-FB-4	RH-FB-4-1	1	$22.76	$4.55	$0.00	$4.55
29	R	AH-FB-1	AH-FB-1-2	1	$43.03	$13.31	$11.03	$24.34
30	DL	AH-FB-1	AH-FB-1-1	4	$43.03	$8.61	$11.03	$19.64
31	H	AH-FB-1	AH-FB-1-1	1	$43.03	$4.55	$0.00	$4.55
32	R	AH-FB-2	AH-FB-2-1	2	$55.52	$26.62	$22.07	$48.69
33	AI	AH-FB-2	AH-FB-2-1	1	$55.52	$11.10	$2.76	$13.86
34	DL	AH-FB-2	AH-FB-2-1	15	$444.13	$32.28	$41.38	$73.65

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Figure 20: Planting Cost Database

The Plant, Island, and Bed ID have all been updated to correspond with each other in order to work between different tables and queries in Access.

In order to calculate maintenance costs, such as mulching and edging, the square footage and linear footage must be determined. Because we previously mapped the Planting Beds in Map Info, we were able to link the information about the surface area and perimeter to Microsoft Access. With the information we collected ourselves and from the information we gained from Ron Klocek, we were able to produce the maintenance cost results, which again corresponded with each individual bed. The results and their related beds are represented below in Figure 21.

flowerbed_ID	surface_area	Perimeter	Mulch_Main_Cost_per_year	Edge_Main_Cost_per_year	Tot_Main_Bed_Cost_per_year
QUAD-FB-5	251	168	$75.93	$95.76	$171.69
SL-FB-2	136	62	$41.14	$35.34	$76.48
MH-FB-11	400	87	$121.00	$49.59	$170.59
MH-FB-5	102	41	$30.86	$23.37	$54.23
MH-FB-6	26	21	$7.87	$11.97	$19.84
MH-FB-10	23	20	$6.96	$11.40	$18.36
MH-FB-8	86	37	$26.02	$21.09	$47.11
MH-FB-9	30	22	$9.08	$12.54	$21.62
MH-FB-7	109	44	$32.97	$25.08	$58.05
DH-FB-5	1787	385	$540.57	$219.45	$760.02
DH-FB-4	67	34	$20.27	$19.38	$39.65
DH-FB-2	291	107	$88.03	$60.99	$149.02
DH-FB-3	1095	292	$331.24	$166.44	$497.68
RH-FB-2	987	167	$298.57	$95.19	$393.76
RH-FB-5	173	52	$52.33	$29.64	$81.97
RH-FB-1	748	201	$226.27	$114.57	$340.84
RH-FB-6	419	90	$126.75	$51.30	$178.05
RH-FB-4	155	53	$46.89	$30.21	$77.10
RH-FB-3	400	97	$121.00	$55.29	$176.29
AH-FB-3	1057	163	$319.74	$92.91	$412.65
AH-FB-1	468	132	$141.57	$75.24	$216.81
AH-FB-2	567	105	$171.52	$59.85	$231.37
QUAD-FB-2	1043	146	$315.51	$83.22	$398.73
QUAD-FB-4	513	81	$155.18	$46.17	$201.35
QUAD-FB-1	345	68	$104.36	$38.76	$143.12
QUAD-FB-3	1034	145	$312.79	$82.65	$395.44
QUAD-FB-7	657	123	$198.74	$70.11	$268.85
QUAD-FB-6	655	122	$198.14	$69.54	$267.68
HL-FB-5	1405	190	$425.01	$108.30	$533.31
HL-FB-4	816	139	$246.84	$79.23	$326.07
HL-FB-3	811	140	$245.33	$79.80	$325.13
CC-FB-9	1937	456	$585.94	$259.92	$845.86
CC-FB-10	1155	141	$349.39	$80.37	$429.76
CC-FB-6	48	37	$14.52	$21.09	$35.61

Record: 53 of 145

Datasheet View

Figure 21: Maintenance Database

Not only were the mulching and edging costs calculated and reported, but a column was designed at the end for the Total Maintenance Cost per year with respect to each planting bed.

These databases are incredible tools. They allowed us not only to calculate these costs, but we were also able to create a number of different maps that were derived from many combinations of these databases. Spreadsheets and databases are useful; however they can get very boring to look at and tough to put into perspective. This is the reason why we have linked our databases with the Map Info program. It will allow Plant Services to obtain an abundant amount of visuals that all include the data we had collected and processed, which in the end will make everything simpler to appreciate and understand.

4.4. Inventory Maps

The previous two E-grounds IQP projects have mapped out the WPI campus using the Map Info program as well. They combined their data with satellite images and created a relatively accurate map of the campus. Our task was to completely map out the planting beds and everything that pertained to them. First, we modified any changes that were to be made to the current flower bed layer in Map Info. For example, we had to delete some of the flower beds near the power house building that were destroyed during the construction. Then we created a layer in Map Info for each perennial flower found on WPI campus. The following is the legend for the Map Info data:

Symbol	Flower Type
	Azalea
	Day Lily
	Rhododendrons
	Shrubs/Bushes
	Black Eyed Susan
	Astilbe

Within the MapInfo program, the layers can be viewed individually or all together, depending on what data you are interested in viewing. The two pictures represented here are examples of what can be seen when viewing the MapInfo data. The first map below, Figure 22, is an example of how just the Black-Eyed Susan's can be shown using Map Info. The second map that is shown below here, Figure 23, is an example of the Rhododendron Layer in Map Info. We were able to zoom out so that it is easier to put the amount of Rhododendrons into perspective.

Figure 22: MapInfo Example of Black Eyed Susan map

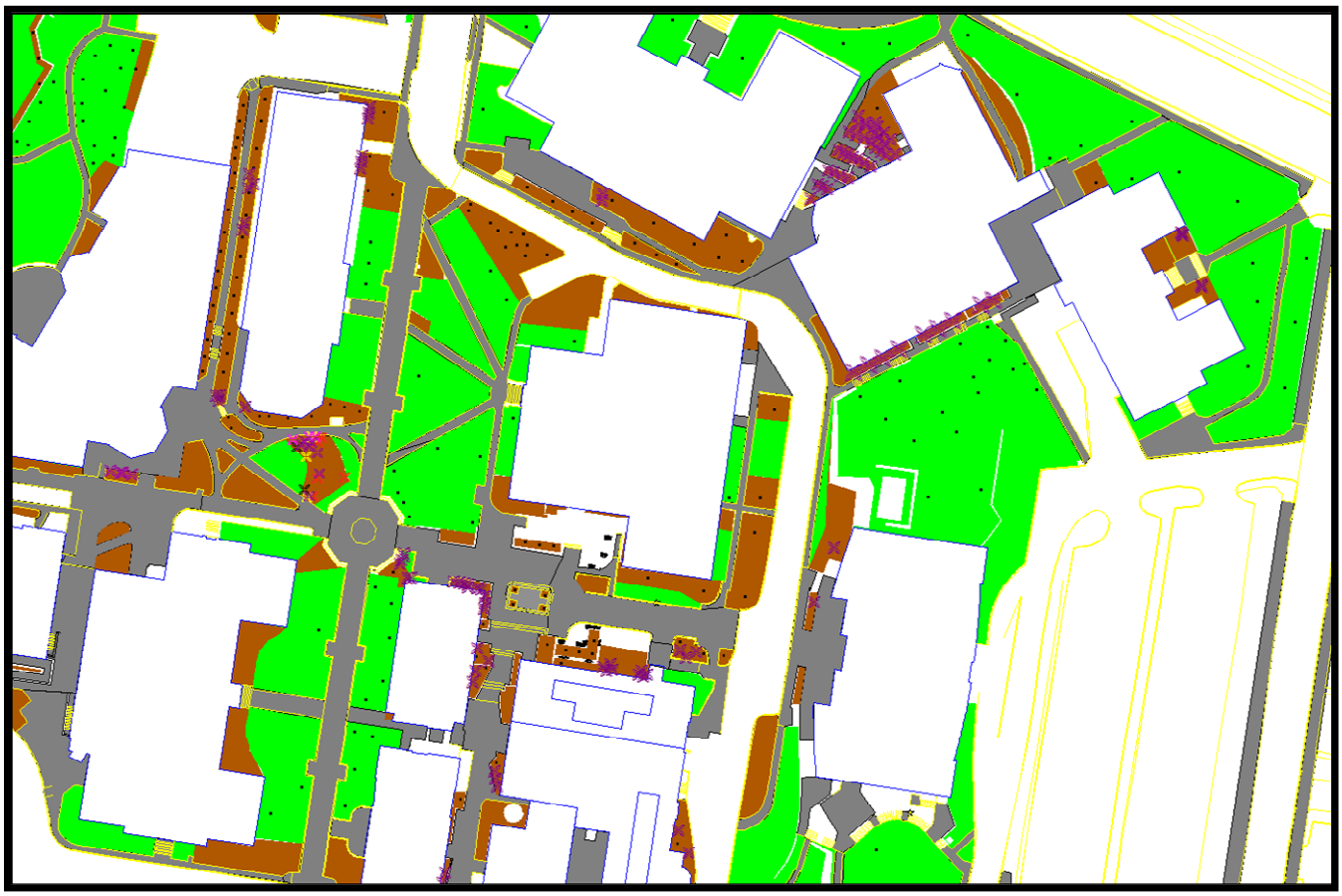


Figure 23: Rhododendron Layer map

4.5. Maps for Planting Costs

The next map we created, shown in Figure 24 determines the Annualized Initial Cost per bed. This is simply the Initial Cost divided by 5, the average number of years before the plant needs to be replaced. Therefore we get a more precise visualization of the

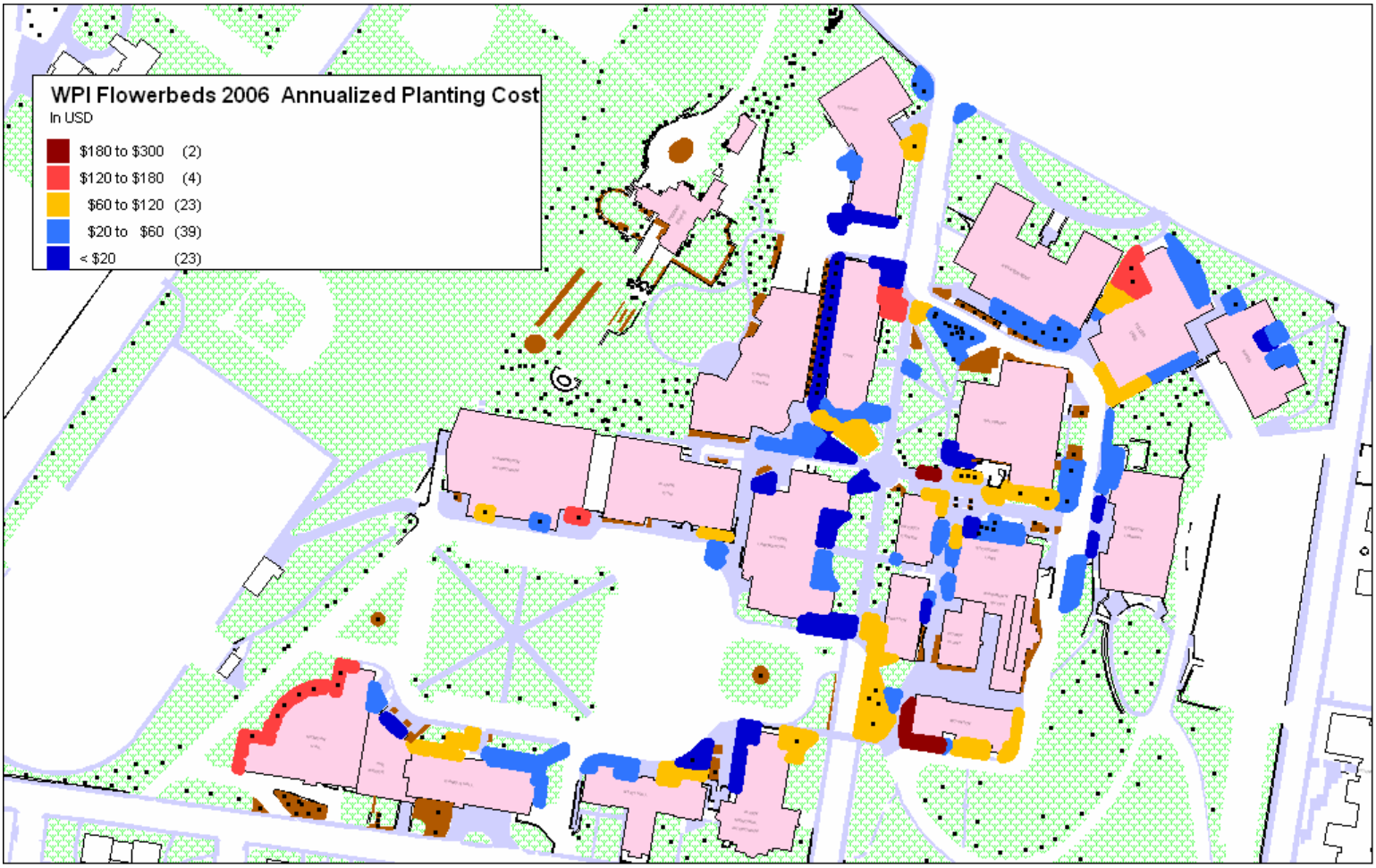


Figure 24: Annualized Planting Cost map

Initial Planting Cost per year. Some of the planting beds do not have plants in them, some are just mulch and trees, and therefore they are shown on the map in their normal brown color. The other price ranges can be seen with respect to the key in the corner of the Annualized Planting Cost map.

Next we took into consideration the maintenance of the plants themselves. This maintenance included the dead heading and the pruning of the plants. We calculated the costs of these two tasks by multiplying the time it takes to complete them by the hourly wage of the worker. We then multiplied that result by two, because pruning and dead heading takes place twice a year, giving us a yearly Plant Maintenance Cost. The map can be seen below in Figure 25.

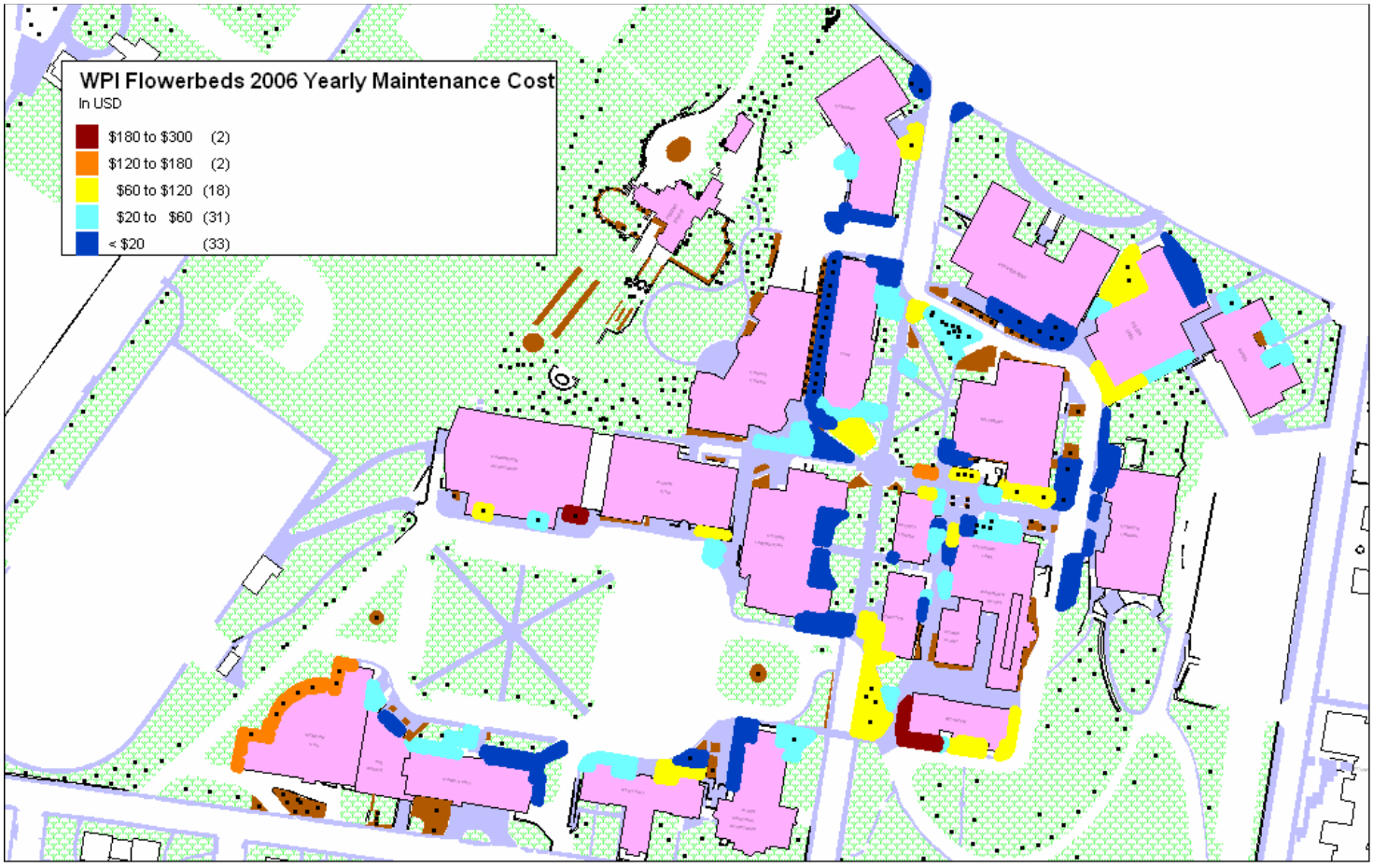


Figure 25: Yearly Plant Maintenance Cost map

Now that we have calculated the annual planting cost and the annual maintenance cost for the plants per bed, we were next able to combine the two data sets and create a

map for the Total Annual Plant Cost per bed. Again, the Total Annual Plant Cost per bed includes the Annualized Planting Cost along with the Yearly Plant Maintenance Cost. This map is shown below in Figure 26.

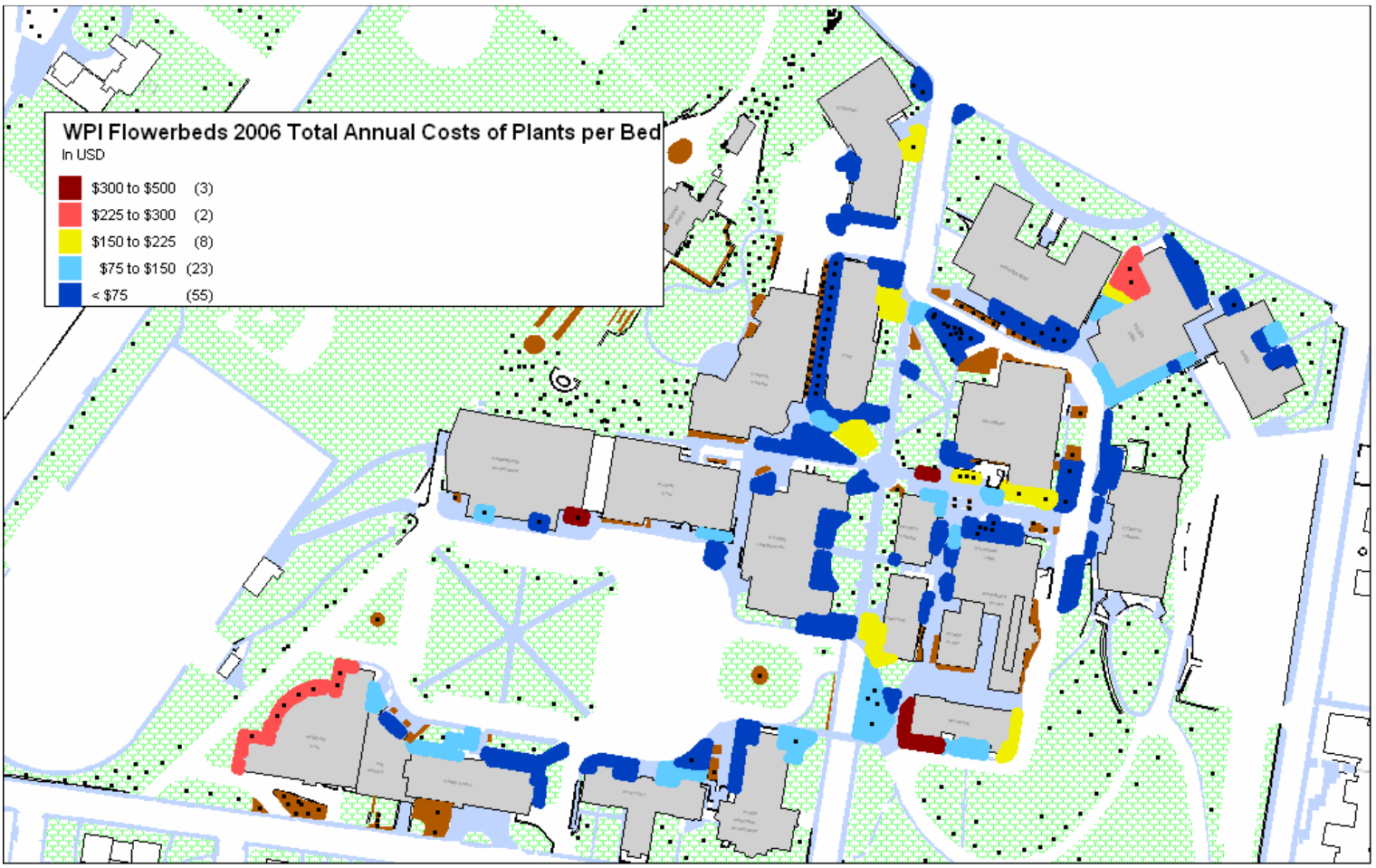


Figure 26: Total Annual Costs of Plants per bed map

4.6. Maps for Maintenance Costs

We talked about maintenance above; however, we also had to take into consideration the maintenance of the beds themselves. The main contributing factors we incorporated were mulching and edging. In order to determine the total mulching cost per bed, there were a few things we had to recognize. One, we found out how much the mulch costs per yard, which was $26.00. We then converted 1 yard to 162 square feet,

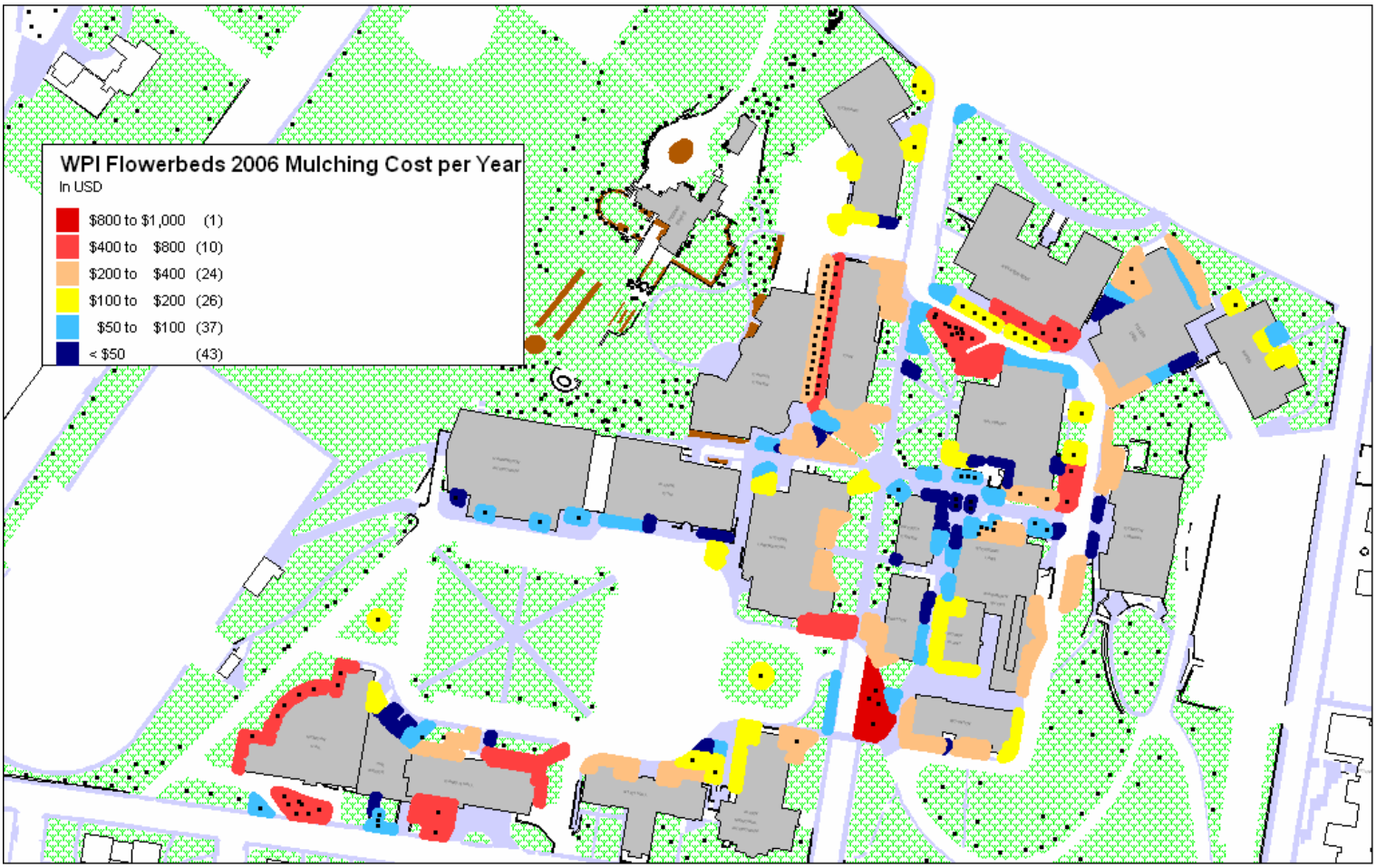
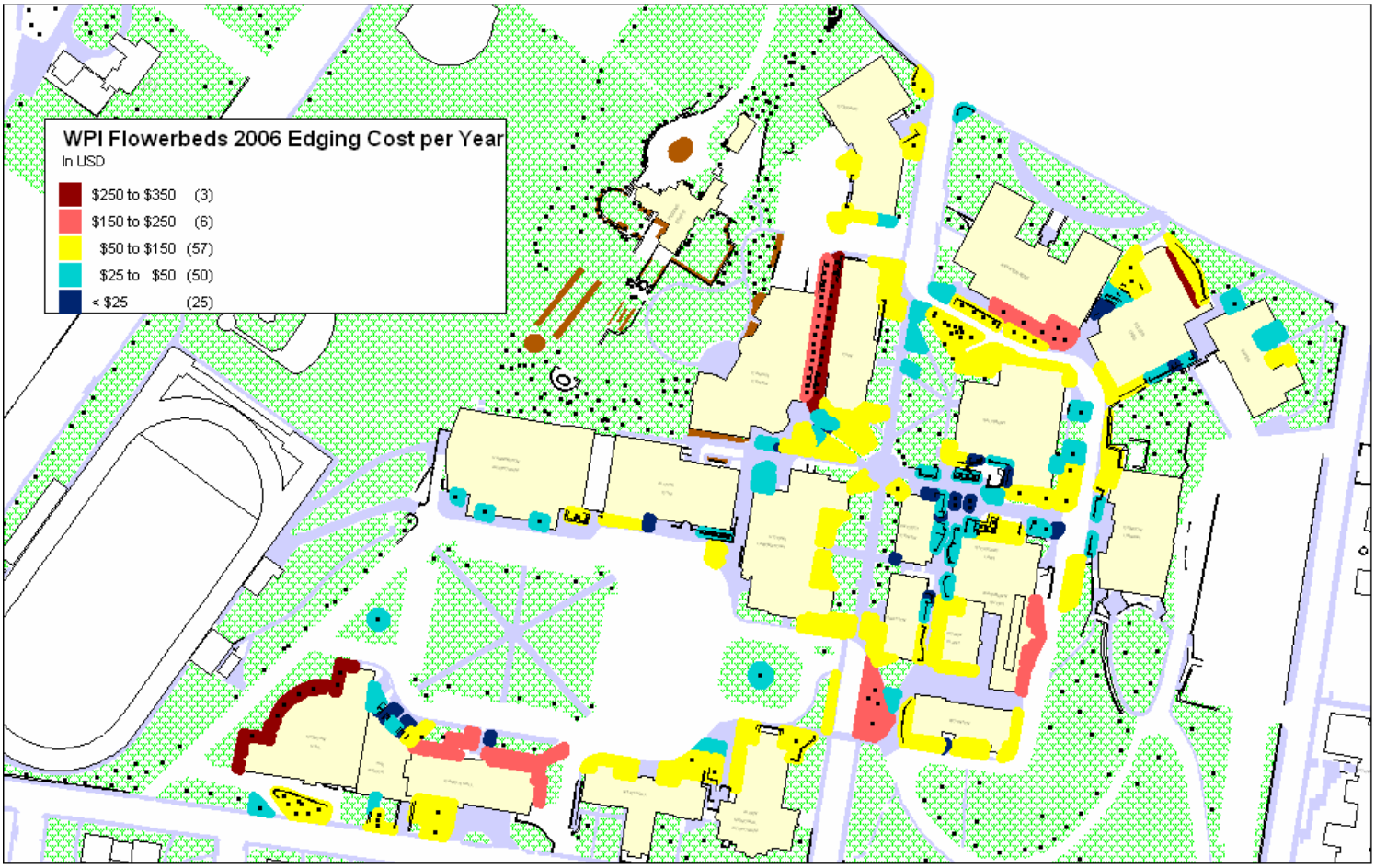


Figure 27: Mulching Cost per year map

which made it possible for us to easily determine how many square feet of mulch were needed per bed because Map Info has already calculated the square footage per bed for us. Second, we had to identify the time it took per yard of mulch to put it down. This

included the truck time of loading and unloading each yard, which we calculated to be around 1.1 hours per yard, or 162 square feet. To put everything together we multiplied the unit cost by the square footage of the bed and to that we added the labor time multiplied by the hourly wage. We then multiplied this result by two, because the mulching of each bed takes place twice a year. This gave us the Mulching Cost per year for each planting bed, which is displayed above in Figure 27.

The edging process was not nearly as complicated as the mulching when configuring the yearly costs. Map Info was able to give us the linear footage per bed. Ron Klocek estimated that it takes about two minutes to edge per linear foot. We multiplied the linear footage of the bed by two to get the time it takes to edge per bed. Next, we simply multiplied the time by the hourly wage, giving us the labor cost. Similarly to mulching, edging takes place twice a year as well. So we multiplied the labor cost by two



to determine the edging cost per year for each planting bed. The Edging Cost per Year is illustrated above in Figure 28.

The next logical map to be created would be a Total Maintenance Cost per Year map. This map is the combination of adding both the mulching costs and the edging costs together. The Total Maintenance Cost per Year map is shown below in Figure 29.

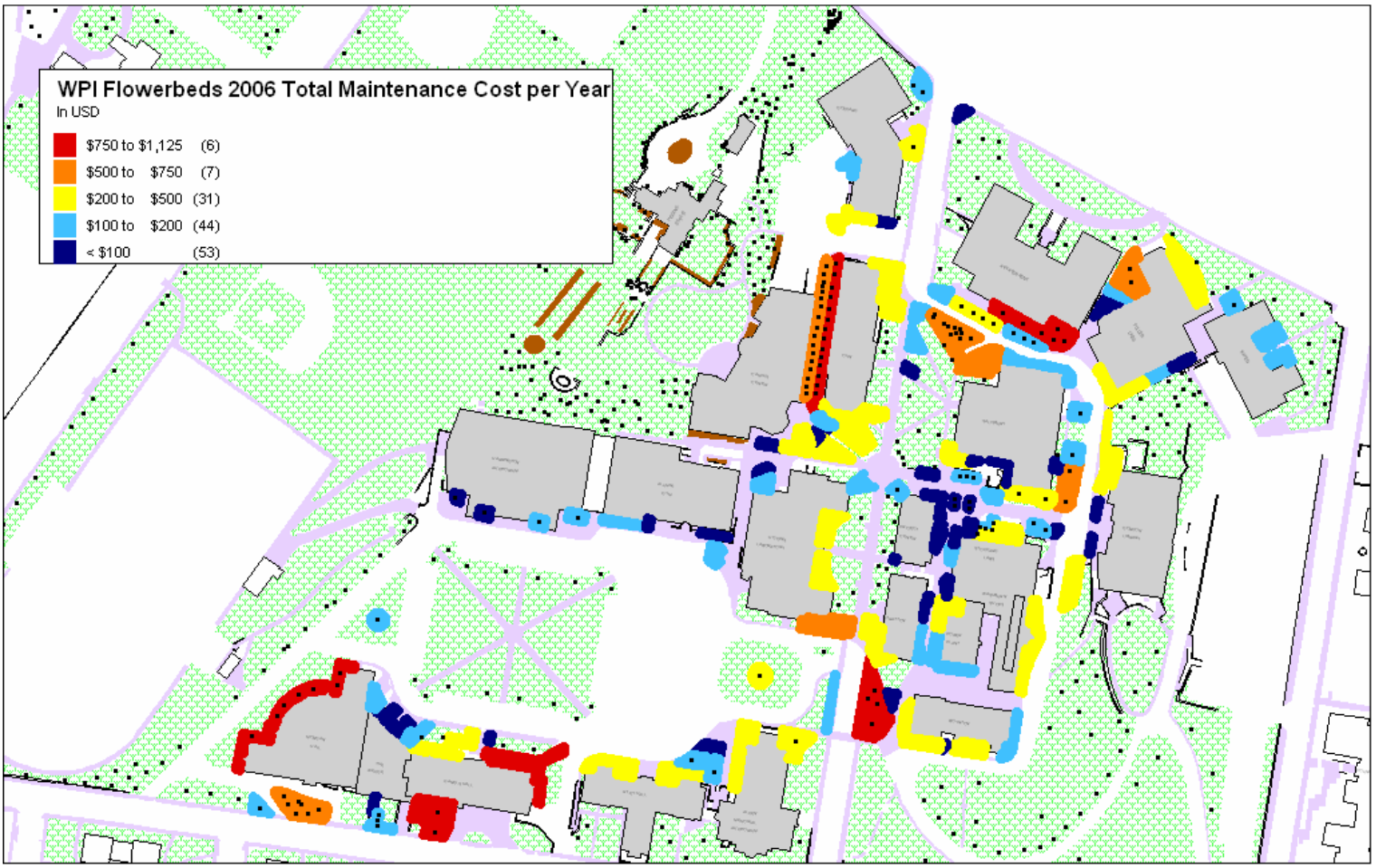


Figure 29: Total Maintenance Cost per Year map

4.7. Total Cost of the Planting Beds

One way we felt we could truly display a lot of useful information was to create a Total Cost per Year map. This map, shown below in Figure 30, adds the Total Annual Cost of Plants per bed to the Total Annual Maintenance Cost per bed, leaving us with the complete Total Annual Cost per bed.

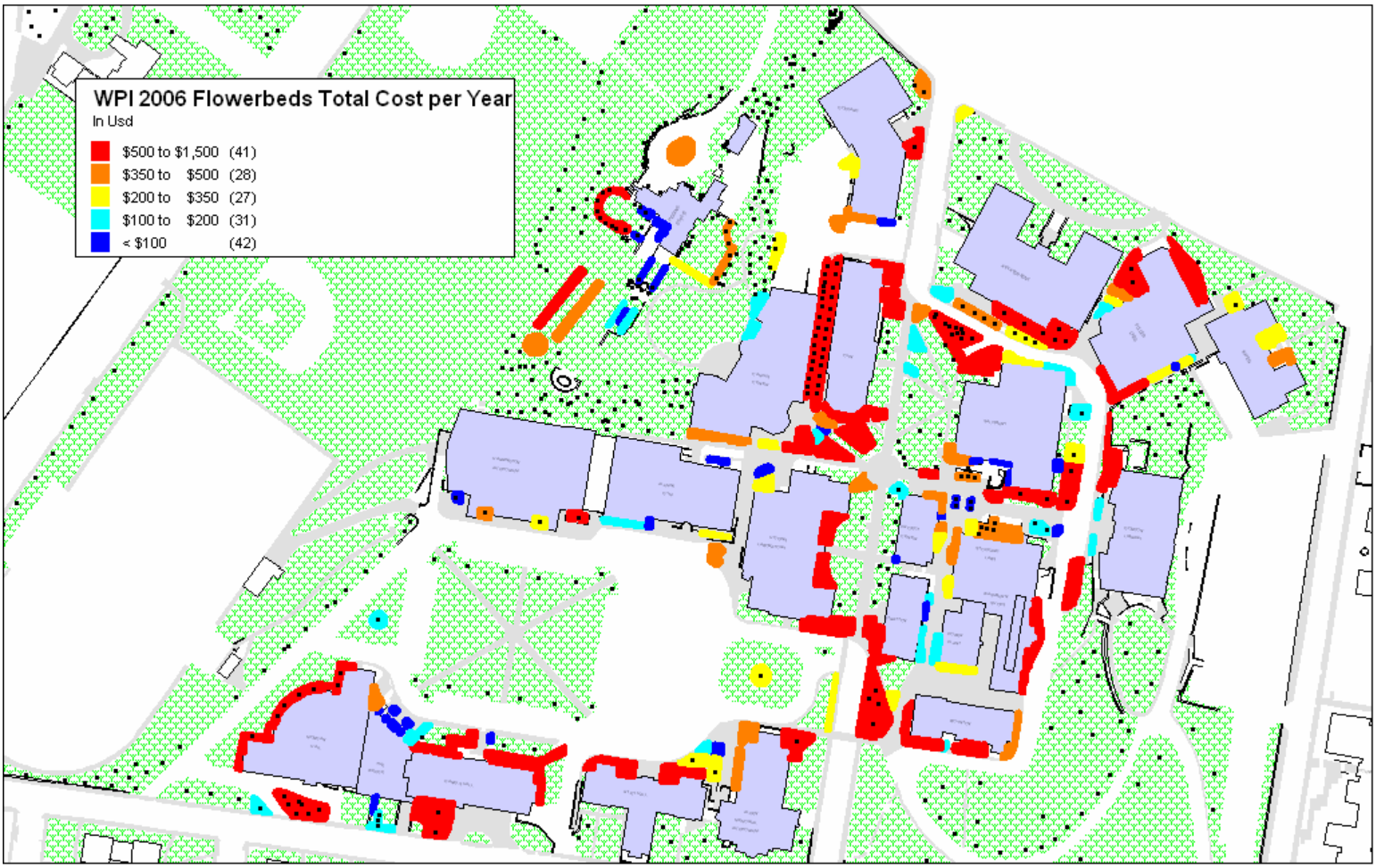


Figure 30: Total Annual Cost per Bed map

5. Analysis

The data from each flower bed within the cost matrix will be analyzed to make sure that it is within its respected priority level. The total average square footage cost was determined for us from the cost matrix. The priority level for each flower bed has been sorted out according to each location. In the analysis we will be able to intertwine both data sets, which will enable us to visually display the campus with the cost and priority levels of each bed overlapped, showing whether or not the bed is up to par with the level of priority we created.

With all the maps we have created, the information they display are great, however they do not quite give any information that can be truly put to use in order to help improve the WPI campus. The most useful, analytical map that we came up with was the Total Cost per Square Foot vs. Priority Levels map. This map displays the Total Cost per Square Foot as the inside color of the planting beds with respect to the color-coded key. It also shows the Priority Levels as the outlined color of the beds with respect to the color-coded key. This enables you to see the money spent per square foot on each bed, along with what the priority level should be. This would quickly let you glance over the WPI Campus and determine which planting beds currently need more attention than others.

This map is the basis of our analysis. We were able to prioritize the main pathways around the WPI campus which also includes that of the WPI Campus Tour Route. By creating a buffer system we were able to isolate the most important beds and then visualize how they compare to the total cost per square foot. The total cost per square foot is directly proportional to the amount of plants and labor put into the

individual beds. Therefore high levels of priority should also have a higher total cost per square foot.

Pictured below, in Figures 31, 32, and 33 are maps of Total Cost per Square Foot vs. Priority Levels. We split up the WPI Campus map to give a better view and perspective of the breakdown for each planting bed.

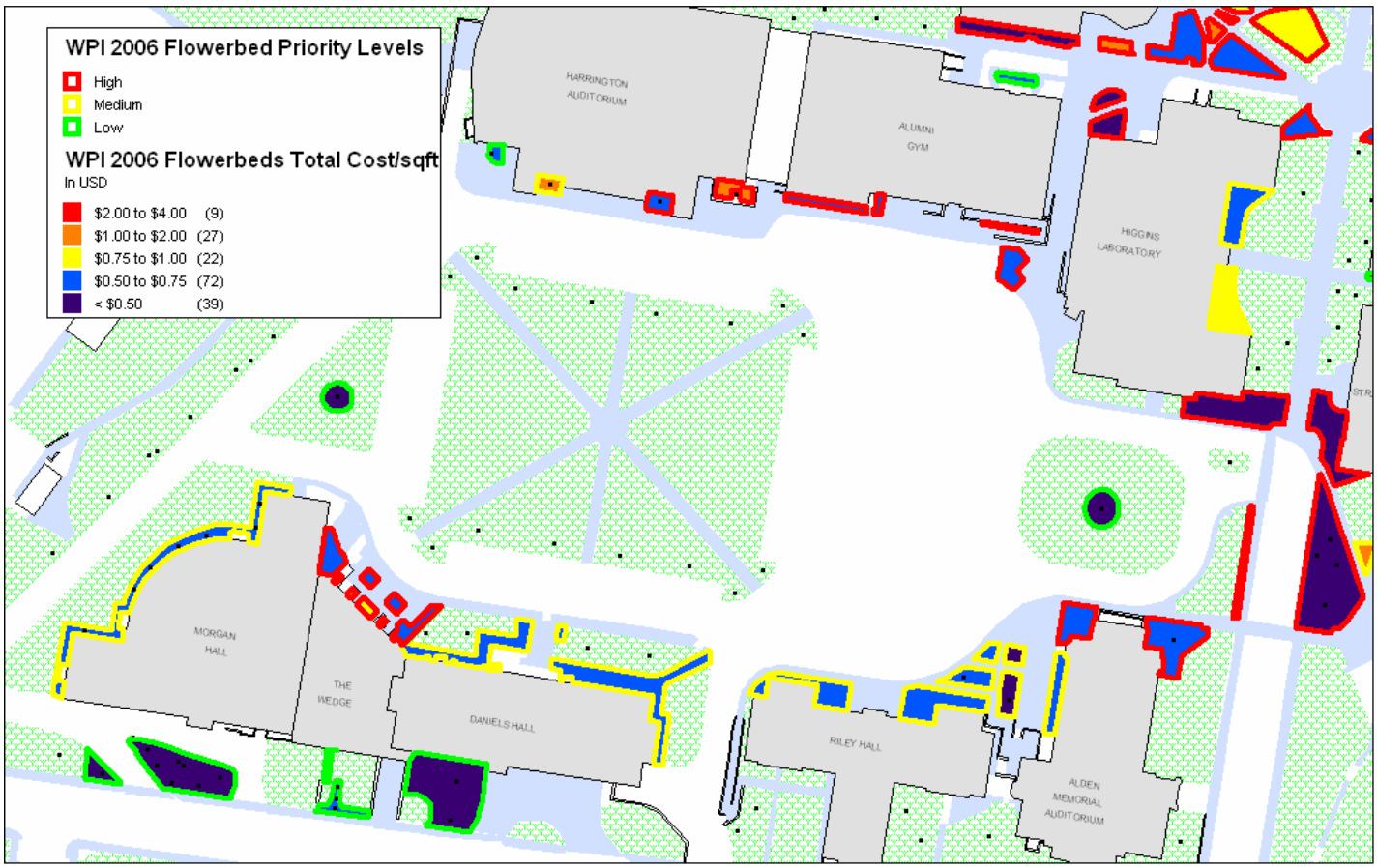


Figure 31: Total Cost per Sq Ft vs. Priority (view 1)

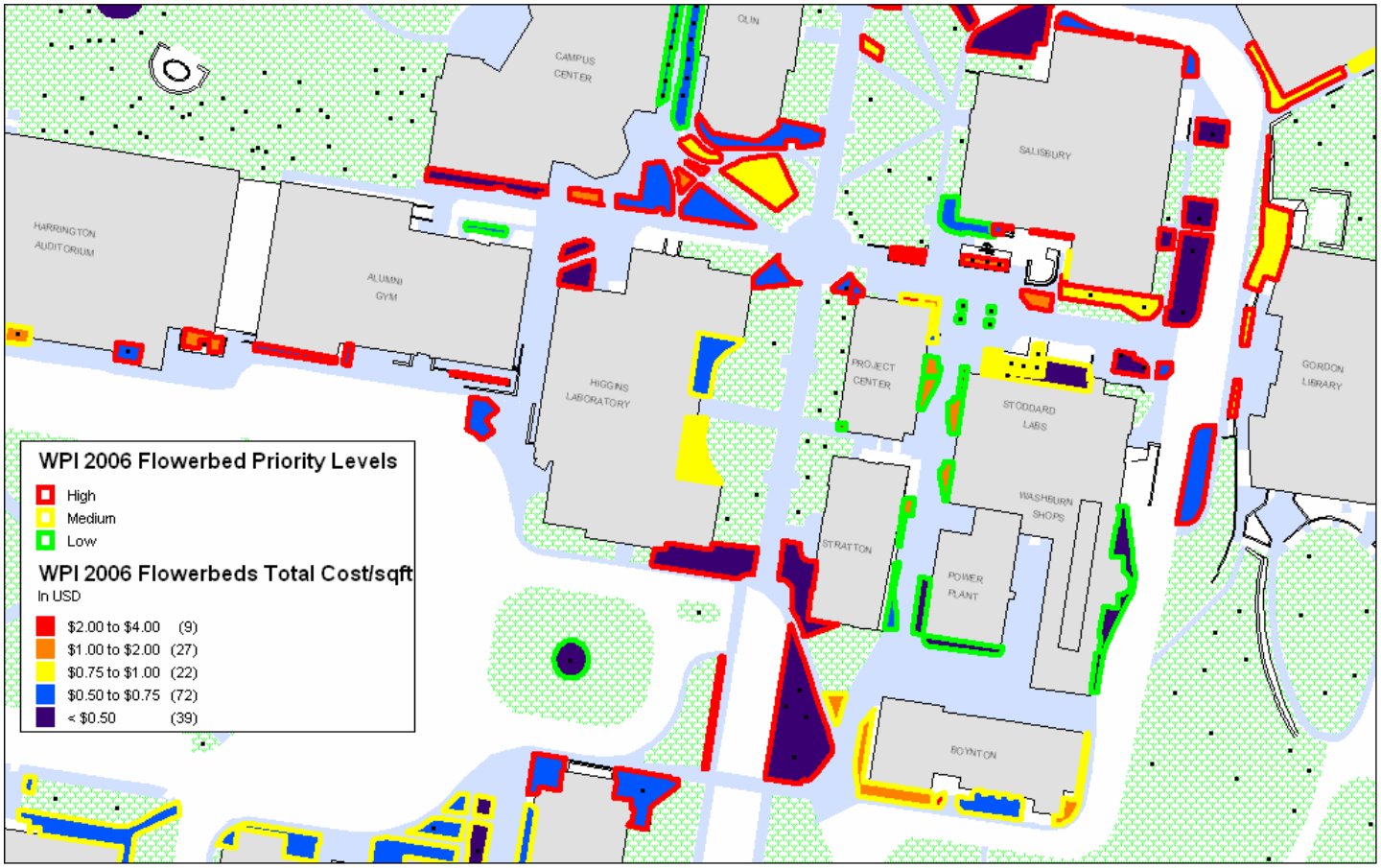


Figure 32: Total Cost per Sq Ft vs. Priority (view 2)

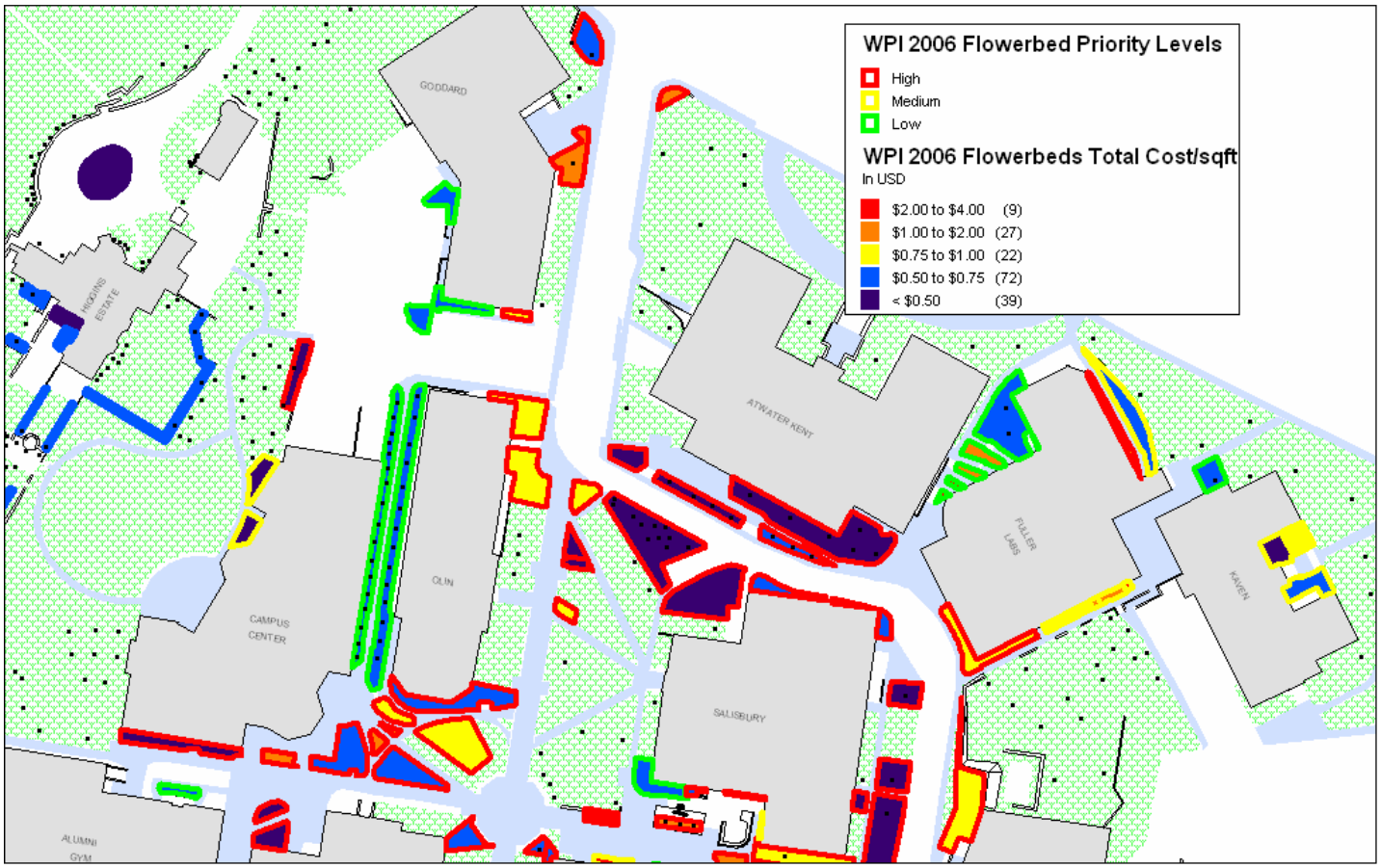


Figure 33: Total Cost per Sq Ft vs. Priority (view 3)

The grand total spent per year is $49,564. That leaves us with an average total cost per square foot of the planting beds is $0.86 per square foot. The maps show that the average should be colored in with yellow. However, you can notice that a large number of the planting beds are below this average. In order to maximize our resources, we must focus on planting beds that have a high priority and a below average cost per square foot. We may also want to look at the planting beds outlined in green, which have a low priority, and if they also have an above average cost per square foot, then it would make sense to take some funds out of those beds and put them towards a high priority bed.

In order to help analyze the Priority Level vs. the Total Cost per Square Foot, we created a chart by combining a few different tables together. We included the Flowerbed ID, Total Cost, Total Cost per Square Foot, and the Priority Level side by side for each planting bed. This presents a simple way to distinguish the necessities of each bed. Table 1 in the appendix displays this chart.

When changes are needed to be made, whether there are additions or subtractions, we have also created a Flower/Plant Inventory Form within Microsoft Access. This form easily allows the user to enter new information about any planting bed they want, making changes quick and simple. An example of this form is shown below in Figure 34.

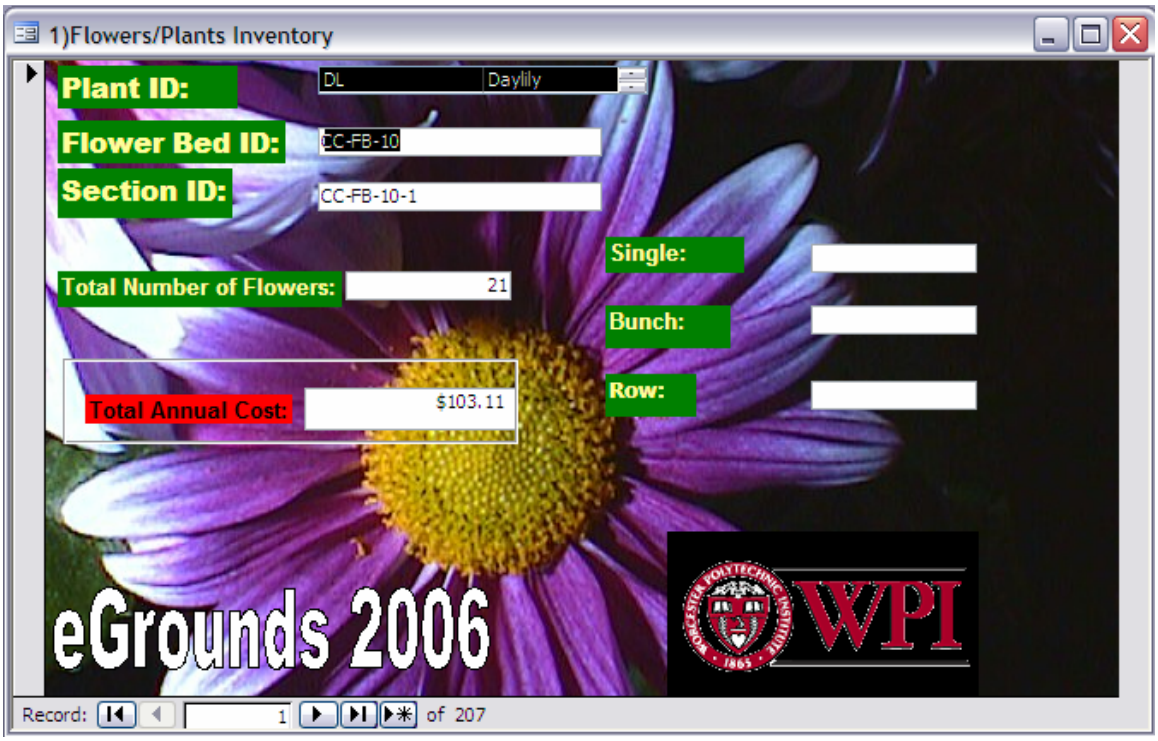


Figure 34: Inventory Form

We have created a Final Report, displaying all of the cost information for each planting bed. Please refer to Table 2 in the appendix to view this data.

6. Recommendations

Based on our research and the development, it is now possible to optimize the planting beds on campus. By determining the value of each planting bed, we have established the individual costs per bed, including the most important; total annual cost per square foot. The next course of action called for was focusing on the desirability and/or location, which we called "priority" of each bed. This enabled an efficient way to visualize and reassess an increase or decrease in the monetary value where necessary. For example, the following shows several beds located in a high priority zone denoted by the red border. However, the interior color is that which is below the average, a value less than $0.86/sqft. The total annual cost per square foot is directly proportional to the amount of labor put into the bed as well as the bed's plant density. If the total annual cost is not equal to or above the average cost and is situated in a high priority zone, reassessment is necessary.

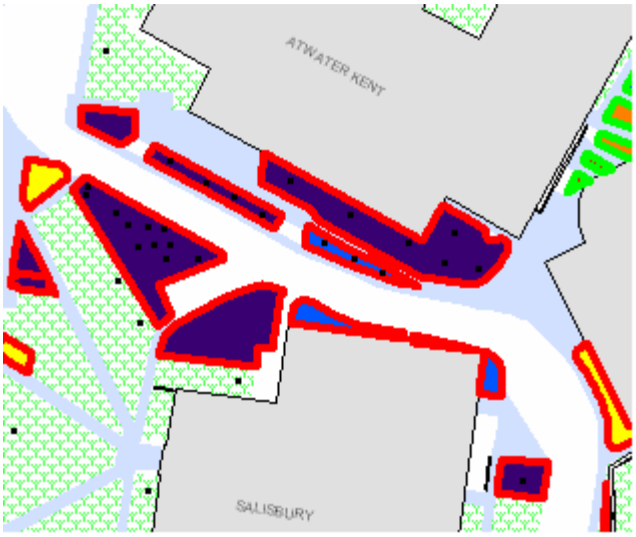


Figure 35: Below Average Beds

In addition to this previous example, the following is from the opposite side of the spectrum. The beds behind the Project Center and between Atwater Kent and Fuller are located in a low priority zone; indicated by the green border. However, the total cost per square foot is of the second highest corresponding color. Again, this is an

indication for a reallocation of funds. There is no reason for such beds to hold such a high monetary value in a low traffic area.

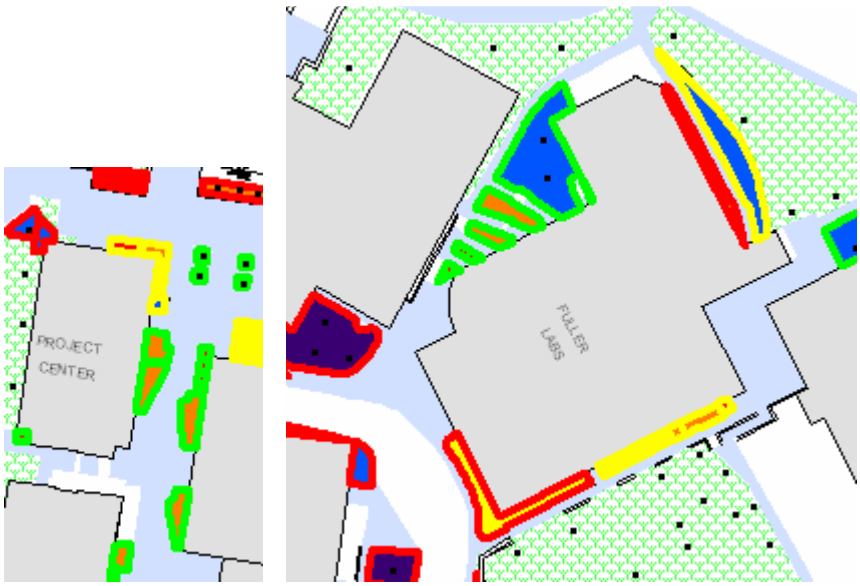


Figure 36: Above Average Beds

A second series of maps has been produced in order to justify the average annual

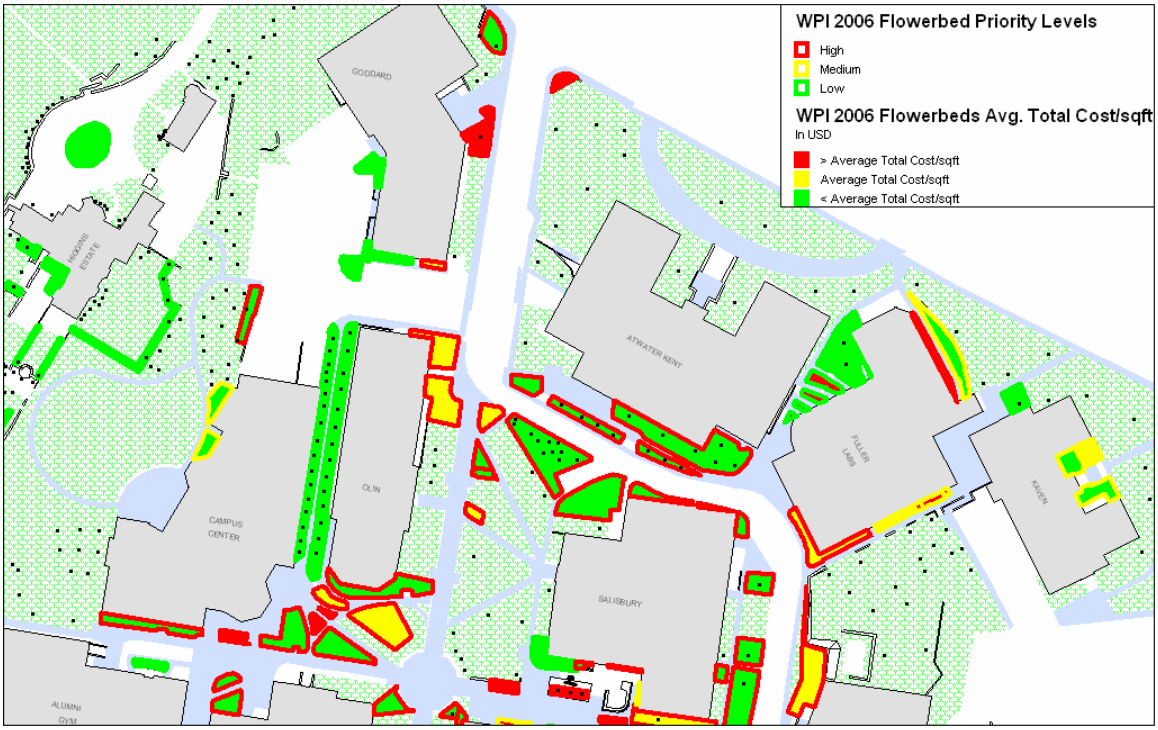


Figure 37: Average Cost/Sqft vs. Priority (View 1)

total cost per square foot. These maps which are similar to the previous maps, now display the flowerbed's relationship to the average cost. By using the same three colors for the levels of priority we can now visualize the problematic beds more readily. The bed's where the interior color does not match that of the bed's border are in need of change. Although the maps below show that most of the beds are in need of renovation, it is possible that they are only a few cents under the average, while some beds are worse than the others. It is our recommendation that the beds which are truly situated in low traffic, low priority zones, be either eliminated or replaced by strictly grass or mulch. It may even be possible to transplant these beds and add then to others where the total annual cost per square foot is far lower than the average.

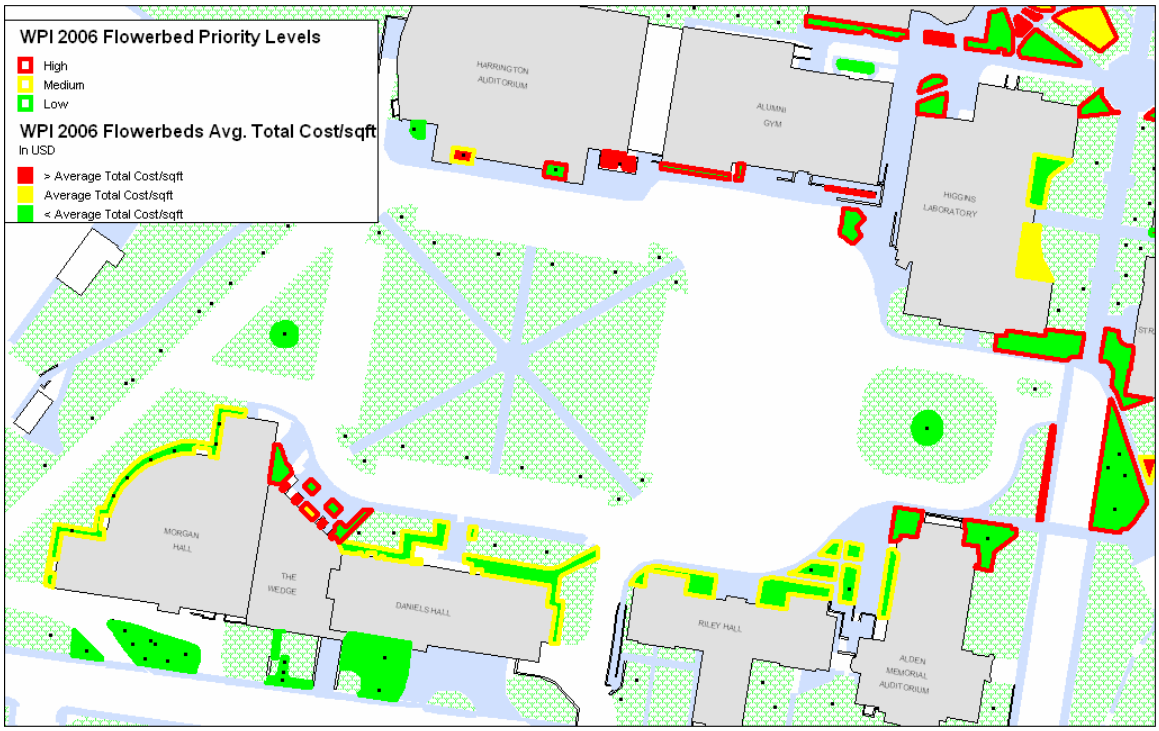


Figure 38: Average Cost/Sqft vs. Priority (View 2)

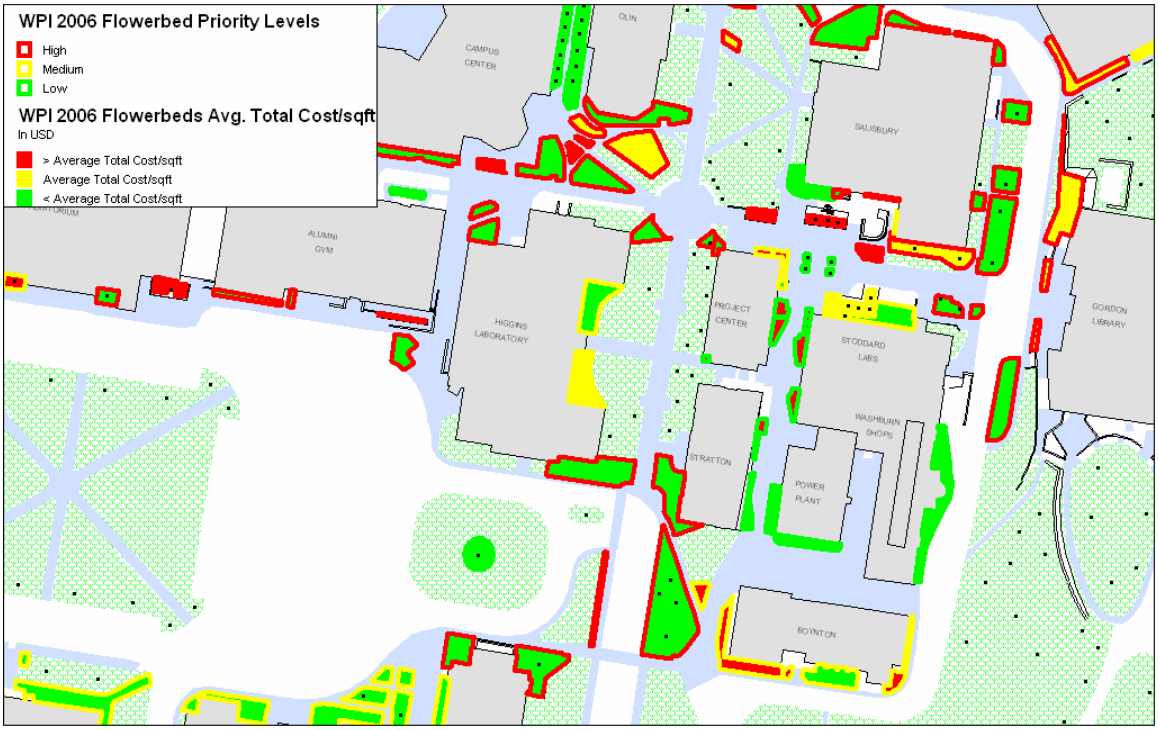


Figure 39: Average Cost/Sqft vs. Priority (View 3)

This project was focused strictly on the upper campus of WPI and its flowerbeds. The E-Campus IQPs of the future will need to encompass the latest additions to the WPI community and its outer campuses. Unfortunately, when we began our research and inventorying, the annuals planted were removed. We were unable to account for the annuals planted for commencement and the summer months. The next E-Grounds IQP project should begin inventorying at the beginning of the school year in order to incorporate for all the plants on campus whether annual or perennial.

Throughout the duration of this project an idea for a system that determines the aesthetic values of the flowers and beds was proposed. However, it was never created. In order to justify the aesthetic value versus the cost of plants, we presumed that with the specific plants used on campus, the more expensive plants held a higher aesthetic value. Ultimately this holds true for the simple reason that the rhododendrons and azaleas planted are bigger, bolder, and essentially more beautiful. However, a system has yet to be developed in order to prove so. Ideally, a survey should be conducted to fellow

students and faculty of WPI in order to rank specific aesthetic values of the plants found on campus. Another thing that was not taken into consideration was the trees planted and what aesthetic value they may hold. Along with a future survey, an experiment needs to be performed as well in order to determine if the trees themselves add beauty and stature to the beds.

Ideally the last project for E-Grounds will be the joining of all the past IQP projects in hopes that one day an easy and manageable information system will be created and individuals will be able to view and access this information online.

7. Appendix

Table 1: Total Cost vs. Total Cost per Sq Ft vs. Tour Priority

Flowerbed ID	Total Cost	Total Cost/per Sqft	Tour priority
DH-FB-1	$820.27	$0.35	5
MH-FB-2	$641.70	$0.37	5
SL-FB-5	$539.60	$0.37	10
HH-FB-9	$365.97	$0.37	0
HH-FB-1	$255.38	$0.38	0
QUAD-FB-2	$398.73	$0.38	8
QUAD-FB-3	$395.44	$0.38	8
QUAD-FB-4	$201.35	$0.39	5
SL-FB-4	$733.07	$0.40	10
SH-FB-1	$1,203.46	$0.40	10
QUAD-FB-6	$267.68	$0.41	10
SL-FB-9	$186.39	$0.41	10
QUAD-FB-7	$268.85	$0.41	8
QUAD-FB-1	$143.12	$0.41	5
SL-FB-8	$158.81	$0.42	10
RH-FB-6	$178.05	$0.42	8
AK-FB-5	$139.28	$0.43	10
AK-FB-2	$1,021.54	$0.44	10
HH-FB-2	$417.67	$0.44	0
HL-FB-5	$618.61	$0.44	10
WASH-FB-14	$137.97	$0.44	10
HH-FB-3	$394.29	$0.44	0
HH-FB-17	$149.99	$0.45	8
AK-FB-4	$257.75	$0.46	10
MH-FB-1	$135.07	$0.46	5
HH-FB-16	$189.84	$0.46	10
HH-FB-18	$122.61	$0.46	8
KH-FB-2	$161.62	$0.47	8
CC-FB-1	$167.98	$0.47	10
WASH-FB-2	$155.99	$0.47	5
HH-FB-19	$304.86	$0.47	10
RH-FB-5	$81.97	$0.47	8
WASH-FB-16	$498.85	$0.48	5
SL-FB-10	$679.04	$0.48	10
WASH-FB-1	$182.07	$0.49	5
CC-FB-2	$87.78	$0.49	10
HH-FB-7	$89.26	$0.49	0
WASH-FB-13	$377.38	$0.49	8
ATHL-FB-2	$146.54	$0.50	5
SL-FB-2	$100.74	$0.50	10
SL-FB-11	$69.71	$0.50	10
CC-FB-8	$590.74	$0.51	5

AK-FB-3	$179.44	$0.51	10
HA-FB-1	$61.68	$0.51	5
DH-FB-2	$149.02	$0.51	10
HH-FB-6	$74.95	$0.51	0
SL-FB-6	$168.16	$0.52	10
AH-FB-2	$293.92	$0.52	10
HH-FB-8	$66.95	$0.52	0
ATHL-FB-1	$136.56	$0.52	5
WASH-FB-15	$52.78	$0.52	10
GH-FB-1	$295.41	$0.53	5
EA-FB-2	$86.36	$0.53	0
MH-FB-5	$54.23	$0.53	10
FA-FB-2	$109.89	$0.54	0
MH-FB-4	$152.23	$0.55	5
CC-FB-11	$425.20	$0.55	10
MH-FB-8	$47.11	$0.55	10
HH-FB-20	$88.60	$0.55	5
HH-FB-0	$182.74	$0.56	0
GL-FB-4	$599.32	$0.56	10
FA-FB-1	$66.78	$0.56	0
SL-FB-2	$76.48	$0.56	10
EA-FB-3	$52.95	$0.56	0
DH-FB-3	$619.39	$0.57	8
AH-FB-1	$265.35	$0.57	8
CC-FB-9	$1,103.36	$0.57	5
HA-FB-5	$155.24	$0.57	10
RH-FB-3	$229.74	$0.57	8
EA-FB-1	$49.08	$0.58	0
FL-FB-5	$758.80	$0.58	5
HH-FB-4	$48.78	$0.58	0
HL-FB-1	$248.91	$0.58	10
SH-FB-5	$124.55	$0.59	10
SH-FB-3	$640.06	$0.59	10
HH-FB-10	$249.64	$0.59	0
DH-FB-4	$39.65	$0.59	8
SH-FB-13	$123.04	$0.59	5
EA-FB-4	$48.44	$0.60	0
HA-FB-6	$45.79	$0.60	10
EA-FB-6	$44.31	$0.61	0
SL-FB-7	$137.03	$0.61	10
AH-FB-3	$650.99	$0.62	10
HH-FB-15	$95.04	$0.62	0
GH-FB-3	$288.32	$0.62	10
FL-FB-7	$509.07	$0.62	8
CC-FB-4	$535.65	$0.62	10
KH-FB-4	$274.71	$0.63	8
EA-FB-5	$31.66	$0.63	0
HH-FB-13	$98.76	$0.64	0

MH-FB-12	$1,212.56	$0.64	8
KH-FB-1	$218.36	$0.64	5
SH-FB-8	$29.00	$0.64	8
HH-FB-14	$56.83	$0.65	0
DH-FB-5	$1,155.75	$0.65	8
OH-FB-1	$659.39	$0.67	10
BH-FB-3	$460.30	$0.67	8
RH-FB-2	$659.96	$0.67	8
MH-FB-11	$267.96	$0.67	10
HH-FB-11	$87.21	$0.67	0
MH-FB-3	$62.90	$0.68	5
RH-FB-1	$507.93	$0.68	8
GH-FB-2	$226.77	$0.68	5
RH-FB-4	$105.99	$0.68	8
QUAD-FB-5	$171.69	$0.68	10
SL-FB-17	$353.84	$0.69	5
SL-FB-16	$40.35	$0.70	10
HA-FB-3	$165.05	$0.71	10
HH-FB-12	$82.70	$0.71	0
HL-FB-3	$593.11	$0.73	8
HL-FB-2	$271.56	$0.74	10
WASH-FB-7	$20.14	$0.75	5
WASH-FB-8	$20.14	$0.75	5
WASH-FB-9	$20.14	$0.75	5
HH-FB-5	$414.40	$0.75	0
GH-FB-5	$82.56	$0.75	10
FL-FB-12	$502.74	$0.75	10
GL-FB-2	$100.49	$0.76	10
MH-FB-7	$82.40	$0.76	10
WASH-FB-10	$18.96	$0.76	5
KH-FB-3	$227.72	$0.76	8
HL-FB-4	$621.78	$0.76	8
GL-FB-1	$840.30	$0.77	10
GL-FB-3	$96.02	$0.79	10
MH-FB-10	$18.36	$0.80	10
WASH-FB-12	$242.51	$0.81	8
SL-FB-12	$745.48	$0.83	10
CC-FB-10	$963.74	$0.83	10
WASH-FB-3	$515.52	$0.84	10
REG-FB-1	$194.74	$0.84	5
SL-FB-1	$121.13	$0.85	10
WASH-FB-11	$184.92	$0.88	8
OH-FB-3	$619.40	$0.88	10
SL-FB-3	$282.99	$0.91	10
OH-FB-2	$844.51	$0.92	10
SL-FB-14	$53.42	$0.95	10
FL-FB-11	$211.16	$0.98	8
CC-FB-7	$251.29	$0.99	10

GH-FB-4	$590.46	$1.01	10
CC-FB-6	$48.37	$1.01	10
CC-FB-3	$194.39	$1.02	10
SH-FB-10	$198.69	$1.03	5
SH-FB-12	$53.45	$1.07	5
AK-FB-1	$177.70	$1.07	10
CC-FB-5	$130.49	$1.08	10
SH-FB-2	$210.65	$1.08	8
SH-FB-11	$96.06	$1.13	5
BH-FB-4	$390.58	$1.14	8
BH-FB-1	$1,036.38	$1.14	8
HA-FB-2	$246.84	$1.14	8
FL-FB-4	$294.01	$1.15	5
MH-FB-9	$35.48	$1.18	10
WASH-FB-4	$227.16	$1.28	5
WASH-FB-5	$268.60	$1.28	5
FL-FB-9	$166.61	$1.29	8
MH-FB-6	$33.70	$1.30	10
SL-FB-13	$30.33	$1.32	8
SL-FB-18	$297.23	$1.55	10
FL-FB-6	$508.75	$1.71	10
FL-FB-3	$213.78	$1.72	5
SH-FB-9	$276.47	$1.82	5
SH-FB-7	$274.53	$1.84	8
HA-FB-4	$516.46	$1.94	10
SL-FB-15	$464.37	$1.98	10
FL-FB-10	$73.56	$1.99	8
BH-FB-2	$133.19	$2.22	8
HA-FB-7	$213.73	$2.37	10
WASH-FB-6	$247.20	$2.55	5
SL-FB-19	$525.05	$2.67	10
FL-FB-2	$159.51	$2.70	5
FL-FB-1	$128.02	$3.12	5
SH-FB-4	$89.75	$3.21	5
SH-FB-6	$323.56	$3.72	8
FL-FB-8	$118.99	$3.97	8
CC-FB-16	$10.87	$5.43	10

Plant ID	Common Name	Genus	Species
Al	Azalea	Rhododendron	viscosa
As	Astilbe	Astilbe	arendsii
BB	Bayberry	Myrica	cerifera
BES	Black Eyed Susan	Rudbeckia	hirta
DL	Daylily	Hemerocallis	minor
H	Hosta	Hosta	maculata
R	Rhododendron	Rhododendron	catawbiense

Table 2: Species Codes

Plant ID	Unit Cost	Labor min to plant	Labor min to deadhead	Labor min to prune	N deadheading per year	N pruning per per year	Staff level
As	$10.00	10	0	0	0	0	1
R	$50.00	60	10	10	2	2	1
Al	$50.00	20	0	5	0	2	1
BES	$10.00	10	5	0	2	0	1
DL	$8.00	10	5	0	2	0	1
BB	$75.00	60	0	10	0	2	1
H	$20.00	10	0	0	0	0	1

Table 3: Plant Costs

Table 4: Final Report

Final Report

Flowerbed ID	AH-FB-1					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	1	$24.34	$216.81	$265.35	$0.57	8
DL	4	$19.64	$216.81	$265.35	$0.57	8
H	1	$4.55	$216.81	$265.35	$0.57	8
Flowerbed ID	AH-FB-2					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
Al	1	$13.86	$231.37	$293.92	$0.52	10
R	2	$48.69	$231.37	$293.92	$0.52	10
Flowerbed ID	AH-FB-3					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	2	$48.69	$412.65	$650.99	$0.62	10
As	2	$5.10	$412.65	$650.99	$0.62	10
Al	8	$110.89	$412.65	$650.99	$0.62	10
DL	15	$73.65	$412.65	$650.99	$0.62	10
Flowerbed ID	AK-FB-1					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
Al	5	$69.31	$83.85	$177.70	$1.07	10

	DL	5	$24.55	$83.85	$177.70	$1.07	10
Flowerbed ID	AK-FB-2						
	Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
	Al	4	$55.45	$880.29	$1,021.54	$0.44	10
	DL	6	$29.46	$880.29	$1,021.54	$0.44	10
	As	3	$7.66	$880.29	$1,021.54	$0.44	10
	R	2	$48.69	$880.29	$1,021.54	$0.44	10
Flowerbed ID	AK-FB-3						
	Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
		0	$0.00	$179.44	$179.44	$0.51	10
Flowerbed ID	AK-FB-4						
	Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
		0	$0.00	$257.75	$257.75	$0.46	10
Flowerbed ID	AK-FB-5						
	Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
		0	$0.00	$139.28	$139.28	$0.43	10
Flowerbed ID	BH-FB-1						
	Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
	R	19	$462.52	$407.52	$1,036.38	$1.14	8
	Al	12	$166.34	$407.52	$1,036.38	$1.14	8

Flowerbed ID BH-FB-2

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	4	$97.37	$35.82	$133.19	$2.22	8

Flowerbed ID BH-FB-3

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
Al	2	$27.72	$286.51	$460.30	$0.67	8
R	6	$146.06	$286.51	$460.30	$0.67	8

Flowerbed ID BH-FB-4

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	8	$194.75	$195.83	$390.58	$1.14	8

Flowerbed ID CC-FB-1

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
As	2	$5.10	$153.06	$167.98	$0.47	10
DL	2	$9.82	$153.06	$167.98	$0.47	10

Flowerbed ID CC-FB-10

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	7	$170.40	$429.76	$963.74	$0.83	10
BES	36	$191.16	$429.76	$963.74	$0.83	10
DL	21	$103.11	$429.76	$963.74	$0.83	10
Al	5	$69.31	$429.76	$963.74	$0.83	10

Flowerbed ID CC-FB-11

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
BES	2	$10.62	$310.32	$425.20	$0.55	10
DL	4	$19.64	$310.32	$425.20	$0.55	10
As	6	$15.31	$310.32	$425.20	$0.55	10
Al	5	$69.31	$310.32	$425.20	$0.55	10

Flowerbed ID CC-FB-2

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	0	$0.00	$87.78	$87.78	$0.49	10

Flowerbed ID CC-FB-3

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	5	$24.55	$96.81	$194.39	$1.02	10
R	3	$73.03	$96.81	$194.39	$1.02	10

Flowerbed ID CC-FB-4

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	3	$73.03	$345.08	$535.65	$0.62	10
Al	6	$83.17	$345.08	$535.65	$0.62	10
DL	7	$34.37	$345.08	$535.65	$0.62	10

Flowerbed ID CC-FB-5

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
As	10	$25.52	$63.39	$130.49	$1.08	10

Al	3	$41.59	$63.39	$130.49	$1.08	10

Flowerbed ID CC-FB-6

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
As	5	$12.76	$35.61	$48.37	$1.01	10

Flowerbed ID CC-FB-7

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	10	$49.10	$119.02	$251.29	$0.99	10
Al	6	$83.17	$119.02	$251.29	$0.99	10

Flowerbed ID CC-FB-9

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	5	$24.55	$845.86	$1,103.36	$0.57	5
R	9	$219.09	$845.86	$1,103.36	$0.57	5
Al	1	$13.86	$845.86	$1,103.36	$0.57	5

Flowerbed ID DH-FB-3

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	5	$121.72	$497.68	$619.39	$0.57	8

Flowerbed ID DH-FB-5

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
Al	4	$55.45	$760.02	$1,155.75	$0.65	8
BB	1	$23.83	$760.02	$1,155.75	$0.65	8
R	13	$316.46	$760.02	$1,155.75	$0.65	8

Flowerbed ID	FL-FB-1					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	4	$97.37	$30.64	$128.02	$3.12	5

Flowerbed ID	FL-FB-10					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	2	$48.69	$24.87	$73.56	$1.99	8

Flowerbed ID	FL-FB-11					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	4	$97.37	$113.79	$211.16	$0.98	8

Flowerbed ID	FL-FB-12					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	6	$146.06	$322.31	$502.74	$0.75	10
DL	7	$34.37	$322.31	$502.74	$0.75	10

Flowerbed ID	FL-FB-2					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	5	$121.72	$37.80	$159.51	$2.70	5

Flowerbed ID	FL-FB-3					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	6	$146.06	$67.72	$213.78	$1.72	5

Flowerbed ID	FL-FB-4					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**

R	7	$170.40	$123.61	$294.01	$1.15	5

Flowerbed ID FL-FB-5

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	10	$243.43	$515.37	$758.80	$0.58	5

Flowerbed ID FL-FB-6

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
Al	5	$69.31	$378.00	$508.75	$1.71	10
As	5	$12.76	$378.00	$508.75	$1.71	10
R	2	$48.69	$378.00	$508.75	$1.71	10

Flowerbed ID FL-FB-7

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	2	$48.69	$375.77	$509.07	$0.62	8
As	6	$15.31	$375.77	$509.07	$0.62	8
Al	5	$69.31	$375.77	$509.07	$0.62	8

Flowerbed ID FL-FB-8

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	4	$97.37	$21.62	$118.99	$3.97	8

Flowerbed ID FL-FB-9

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	4	$97.37	$69.23	$166.61	$1.29	8

Flowerbed ID	GH-FB-1					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
DL	5	$24.55	$270.86	$295.41	$0.53	5

Flowerbed ID	GH-FB-2					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	3	$73.03	$153.74	$226.77	$0.68	5

Flowerbed ID	GH-FB-3					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
DL	4	$19.64	$192.00	$288.32	$0.62	10
Al	4	$55.45	$192.00	$288.32	$0.62	10
BES	4	$21.24	$192.00	$288.32	$0.62	10

Flowerbed ID	GH-FB-4					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	7	$170.40	$249.66	$590.46	$1.01	10
R	7	$170.40	$249.66	$590.46	$1.01	10

Flowerbed ID	GH-FB-5					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
DL	4	$19.64	$62.92	$82.56	$0.75	10

Flowerbed ID	GL-FB-1					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	12	$292.12	$478.87	$840.30	$0.77	10

Al	5	$69.31	$478.87	$840.30	$0.77	10

Flowerbed ID GL-FB-2

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	1	$24.34	$76.14	$100.49	$0.76	10

Flowerbed ID GL-FB-3

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	1	$24.34	$71.68	$96.02	$0.79	10

Flowerbed ID GL-FB-4

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	5	$121.72	$421.29	$599.32	$0.56	10
DL	3	$14.73	$421.29	$599.32	$0.56	10
Al	3	$41.59	$421.29	$599.32	$0.56	10

Flowerbed ID HA-FB-2

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	30	$147.30	$99.54	$246.84	$1.14	8

Flowerbed ID HA-FB-3

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	12	$58.92	$106.13	$165.05	$0.71	10

Flowerbed ID HA-FB-4

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	78	$382.98	$133.48	$516.46	$1.94	10

Flowerbed ID HA-FB-7

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	28	$137.48	$76.25	$213.73	$2.37	10

Flowerbed ID HL-FB-1

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	14	$68.74	$180.17	$248.91	$0.58	10

Flowerbed ID HL-FB-2

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
As	2	$5.10	$165.70	$271.56	$0.74	10
R	1	$24.34	$165.70	$271.56	$0.74	10
Al	2	$27.72	$165.70	$271.56	$0.74	10
R	2	$48.69	$165.70	$271.56	$0.74	10

Flowerbed ID HL-FB-3

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	5	$24.55	$325.13	$593.11	$0.73	8
R	10	$243.43	$325.13	$593.11	$0.73	8

Flowerbed ID HL-FB-4

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	5	$24.55	$326.07	$621.78	$0.76	8
Al	2	$27.72	$326.07	$621.78	$0.76	8
R	10	$243.43	$326.07	$621.78	$0.76	8

Flowerbed ID	HL-FB-5					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
DL	4	$19.64	$533.31	$618.61	$0.44	10
Al	4	$55.45	$533.31	$618.61	$0.44	10
As	4	$10.21	$533.31	$618.61	$0.44	10

Flowerbed ID	KH-FB-1					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	3	$73.03	$145.33	$218.36	$0.64	5

Flowerbed ID	KH-FB-2					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
As	5	$12.76	$148.86	$161.62	$0.47	8

Flowerbed ID	KH-FB-3					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	4	$97.37	$130.35	$227.72	$0.76	8

Flowerbed ID	KH-FB-4					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
As	4	$10.21	$191.47	$274.71	$0.63	8
R	3	$73.03	$191.47	$274.71	$0.63	8

Flowerbed ID	MH-FB-11					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	4	$97.37	$170.59	$267.96	$0.67	10

Flowerbed ID	MH-FB-12					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	12	$292.12	$920.44	$1,212.56	$0.64	8

Flowerbed ID	MH-FB-6					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
Al	1	$13.86	$19.84	$33.70	$1.30	10

Flowerbed ID	MH-FB-7					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	1	$24.34	$58.05	$82.40	$0.76	10

Flowerbed ID	MH-FB-9					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
Al	1	$13.86	$21.62	$35.48	$1.18	10

Flowerbed ID	OH-FB-1					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	3	$73.03	$431.15	$659.39	$0.67	10
DL	4	$19.64	$431.15	$659.39	$0.67	10
R	5	$121.72	$431.15	$659.39	$0.67	10
Al	1	$13.86	$431.15	$659.39	$0.67	10

Flowerbed ID	OH-FB-2					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
Al	7	$97.03	$356.12	$844.51	$0.92	10

DL	25	$122.75	$356.12	$844.51	$0.92	10
BES	12	$63.72	$356.12	$844.51	$0.92	10
As	11	$28.07	$356.12	$844.51	$0.92	10
R	1	$24.34	$356.12	$844.51	$0.92	10
Al	11	$152.48	$356.12	$844.51	$0.92	10

Flowerbed ID OH-FB-3

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
BES	14	$74.34	$291.28	$619.40	$0.88	10
R	3	$73.03	$291.28	$619.40	$0.88	10
R	3	$73.03	$291.28	$619.40	$0.88	10
DL	5	$24.55	$291.28	$619.40	$0.88	10
Al	6	$83.17	$291.28	$619.40	$0.88	10

Flowerbed ID RH-FB-1

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
Al	1	$13.86	$340.84	$507.93	$0.68	8
R	2	$48.69	$340.84	$507.93	$0.68	8
DL	10	$49.10	$340.84	$507.93	$0.68	8
Al	4	$55.45	$340.84	$507.93	$0.68	8

Flowerbed ID RH-FB-2

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority

Al	3	$41.59	$393.76	$659.96	$0.67	8
R	6	$146.06	$393.76	$659.96	$0.67	8
DL	16	$78.56	$393.76	$659.96	$0.67	8

Flowerbed ID RH-FB-3

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	1	$24.34	$176.29	$229.74	$0.57	8
H	1	$4.55	$176.29	$229.74	$0.57	8
DL	5	$24.55	$176.29	$229.74	$0.57	8

Flowerbed ID RH-FB-4

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
H	1	$4.55	$77.10	$105.99	$0.68	8
R	1	$24.34	$77.10	$105.99	$0.68	8

Flowerbed ID SH-FB-1

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
BES	28	$148.68	$1,054.78	$1,203.46	$0.40	10

Flowerbed ID SH-FB-10

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
Al	4	$55.45	$94.56	$198.69	$1.03	5
R	2	$48.69	$94.56	$198.69	$1.03	5

Flowerbed ID SH-FB-11

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority

R	2	$48.69	$47.37	$96.06	$1.13	5

Flowerbed ID SH-FB-12

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	2	$9.82	$43.63	$53.45	$1.07	5

Flowerbed ID SH-FB-2

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
Al	3	$41.59	$96.04	$210.65	$1.08	8
R	3	$73.03	$96.04	$210.65	$1.08	8

Flowerbed ID SH-FB-3

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	40	$196.40	$443.66	$640.06	$0.59	10

Flowerbed ID SH-FB-4

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
Al	5	$69.31	$20.44	$89.75	$3.21	5

Flowerbed ID SH-FB-6

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	2	$48.69	$49.69	$323.56	$3.72	8
Al	5	$69.31	$49.69	$323.56	$3.72	8
R	6	$146.06	$49.69	$323.56	$3.72	8
DL	2	$9.82	$49.69	$323.56	$3.72	8

Flowerbed ID SH-FB-7

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
Al	3	$41.59	$86.68	$274.53	$1.84	8
R	5	$121.72	$86.68	$274.53	$1.84	8
DL	5	$24.55	$86.68	$274.53	$1.84	8

Flowerbed ID SH-FB-9

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	5	$121.72	$75.62	$276.47	$1.82	5
Al	5	$69.31	$75.62	$276.47	$1.82	5
DL	2	$9.82	$75.62	$276.47	$1.82	5

Flowerbed ID SL-FB-1

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	10	$49.10	$72.03	$121.13	$0.85	10

Flowerbed ID SL-FB-10

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	5	$121.72	$529.60	$679.04	$0.48	10
Al	2	$27.72	$529.60	$679.04	$0.48	10

Flowerbed ID SL-FB-12

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	8	$194.75	$373.98	$745.48	$0.83	10
DL	36	$176.76	$373.98	$745.48	$0.83	10

Flowerbed ID	SL-FB-15					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
DL	42	$206.22	$108.71	$464.37	$1.98	10
Al	2	$27.72	$108.71	$464.37	$1.98	10
R	5	$121.72	$108.71	$464.37	$1.98	10
Flowerbed ID	SL-FB-17					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
R	4	$97.37	$227.00	$353.84	$0.69	5
DL	6	$29.46	$227.00	$353.84	$0.69	5
Flowerbed ID	SL-FB-18					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
DL	40	$196.40	$100.83	$297.23	$1.55	10
Flowerbed ID	SL-FB-19					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
DL	13	$63.83	$96.07	$525.05	$2.67	10
R	15	$365.15	$96.07	$525.05	$2.67	10
Flowerbed ID	SL-FB-3					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**
DL	30	$147.30	$135.69	$282.99	$0.91	10
Flowerbed ID	SL-FB-4					
Plant ID	**Total # of Flowers**	**Total Annual Cost**	**Total Maintenance Cost/Year**	**Total Cost**	**Total Cost/sqft**	**Tour Priority**

R	2	$48.69	$684.39	$733.07	$0.40	10

Flowerbed ID WASH-FB-11

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
Al	1	$13.86	$98.03	$184.92	$0.88	8
R	3	$73.03	$98.03	$184.92	$0.88	8

Flowerbed ID WASH-FB-12

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	11	$54.01	$146.91	$242.51	$0.81	8
Al	3	$41.59	$146.91	$242.51	$0.81	8

Flowerbed ID WASH-FB-13

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	10	$49.10	$328.28	$377.38	$0.49	8

Flowerbed ID WASH-FB-3

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	8	$194.75	$306.91	$515.52	$0.84	10
Al	1	$13.86	$306.91	$515.52	$0.84	10

Flowerbed ID WASH-FB-4

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
DL	7	$34.37	$92.04	$227.16	$1.28	5
R	3	$73.03	$92.04	$227.16	$1.28	5
Al	2	$27.72	$92.04	$227.16	$1.28	5

Flowerbed ID WASH-FB-5

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
R	3	$73.03	$101.72	$268.60	$1.28	5
Al	5	$69.31	$101.72	$268.60	$1.28	5
DL	5	$24.55	$101.72	$268.60	$1.28	5

Flowerbed ID WASH-FB-6

Plant ID	Total # of Flowers	Total Annual Cost	Total Maintenance Cost/Year	Total Cost	Total Cost/sqft	Tour Priority
Al	3	$41.59	$59.55	$247.20	$2.55	5
R	6	$146.06	$59.55	$247.20	$2.55	5

8. Annotated Bibliography

Grounds Maintenance

Conover, Herbert S. Grounds Maintenance Handbook. 3rd Ed. Vol. Viii. New York: McGraw-Hill, 1977.

> This book adequately provides the background essentials for industrial grounds maintenance. Although published in 1977, it still provides important ideas and concepts that are still used today. Searched with the string, "School grounds-Maintenance and repair"

Woods, Joan. A guide to the Management and Maintenance of School Grounds. Winchester, New Hampshire: Learning through Landscapes, 1996.

> Hand-book on how to make and keep your school looking the best to its ability taking into account for specific costs and the tasks at hand. Searched with the string, "Maintenance and repair"

Design

Newton, Norman T. Design on the Land: The Development of Landscape Architecture. Cambridge, Massachusetts: Harvard University Press, 1971.

> The book goes throughout history and examines the architecture of many different cultures. The book has a nice approach to comparing the building with its landscape. This book would be useful for looking at different ideas for designing WPI's flower beds. Searched with the string, "Landscape architecture"

Gaines, Thomas A. The Campus as a Work of Art. New York: Praeger Publishers, 1991.

This book depicted exactly what makes a successful campus. Although it talks mostly about architecture in relation to buildings, it does have some solid background information about landscaping as a key component. This book explains why eye-catching landscaping attracts many students and makes them feel comfortable when entering the college world. Searched with the string, "School grounds-Maintenance and repair"

Bareither, Harlan D. University Space Planning. Chicago: University of Illinois Press, 1968.

This book examines the concept of how "space" symbolizes the growth and development of an institution of higher education. Also covered in this book is a description of the planning process on how to create a campus that displays a visual impact on the people around it. There is also a section that describes and defines popular terms that are used to help better understand the proper process. Searched with the string, "landscaping"

Phillips, Leonard E. Parks : Design and Management. Vol. Ix. New York: McGraw-Hill, 1996.

A how to guide when dealing with a busy environment and growing annuals and perennials, tree and shrub planting techniques, ornamental grasses as well as Turf management. There is also a section on integrated pest management and the recommended annuals and perennials for certain areas. Searched with the string, "Landscape architecture"

Flowers/Plants

Crocker, Henry. Flowers: A guide for you garden Volumes I & II, Harry N. Abrams, Inc., Publishers, New York, 1968.

This is an extremely relevant source. In this double volume handbook, you can find just about any flower or plant you want, and along with the name it gives you what it needs to survive and how you should take care of it.

Landscaping

Crockett, James Underwood. Landscape Gardening, Time-Life Books, Inc., New York, 1971.

This book may help us, however I don't think we will be too concerned about the layout of our beds. We just want continuous color. This book does talk about great layout techniques for landscape gardening.

Harker, Donald. Landscape Restoration Handbook. Vol. Vi. Boca Raton: Lewis, 1993.

This book starts to target in on specifics for our experiment. The restoration and resurrection of certain plants and landscape designs can be foreseen within its context. Searched with the string, "Landscape"

Weddle, A.E. Landscape Techniques. Great Britain: William Heinemann Ltd, 1979

This book is from England and was complied by the Landscape Institute. It is a key book when researching the best technique for maintaining flower beds. This book is great because it has detailed pictures of everything they talk about. Searched with the string, "Landscape"

Forman T.T. Richard and Gordon, Michel. Landscape Ecology. New York: John Wiley & Sons, Inc., 1986

This book is different from any other traditional landscaping book. It deals with a more scientific approach to landscaping rather than an artistic one. It also deals with maintaining flowers dynamically rather than the traditional static approach. This book will help us maximize the flower growth rate in campus flower beds. Searched with the string, "landscape"

Austin, Richard L. Graphic Standards for Landscape Architecture. New York: Van Nostrand Reinhold Company, 1986.

This book includes many topics that could very well be useful for our project. It defines environmental design systems for on-site work. It talks about community development standards and how to map them out. The main section of use for us would be the section on site modification systems. The chapter includes plant materials, earthwork, and ideas and solutions for site improvements. Searched with the string, "grounds maintenance"

Carpenter, Jot D. Handbook of Landscape Architectural Construction. Washington DC: The Landscape Architecture Foundation, 1976

This is a great reference source, filled with to excess with information and standards of landscape architecture. Included in this text is a list of different types of landscaping and the standards and factors involved with each. It also has a section on the environmental impact of landscape construction. This handbook may help us get well on our way to understanding a landscape system, how it works, and how to strategize when creating ourselves. Searched with the string, "landscape architecture"

Downing, Andrew Jackson. Theory and Practice of Landscape Gardening. Little Compton, Rhode Island: Theophrastus Publishers: 1977

This book is good for general reference on landscaping at different locations. It goes into detail around each particular type of building and develops different types of landscaping strategies. It also briefly discusses ground maintenance. Found this book under keyword search "Landscaping"

Gardening/Others

Harmon, David and Putney, Allen D. The Full Value of Parks: From Economics to the Intangible. Lanham, Maryland: Rowman & Littlefield Publishers: 2003

This book is only good for one chapter in which it deals with managing parks. Otherwise the book only deals with how we should protect National parks and such. Found this book under keyword search "Landscaping"

Burrell, C, ed. The Sunny Border. #172th ed. Brooklyn, NY: Brooklyn Botanic Garden, 2002.

This book is an ideal read for our group because it focuses strictly on color and designing gardens of perennials for beautiful, multifaceted blooms. Throughout the book it focuses mainly on the ground rules of perennials with planting and maintenance tips for 75 plants and roughly a 100 flowering shrubs. Each are categorized by their moisture and climate preference.

Welch, Dr. William C. "Perennial Garden Color." The Southern Garden. 26 Sept. 2005 <http://aggie-horticulture.tamu.edu/southerngarden/per1.pdf>.

Offers insight to maintaining and working with perennial gardens, especially those with mixed plants and shrubs, woodland gardens, contemporary cottage gardens, and perennial borders.

Grenier, D, B C. Kaae, and M L. Miller. "Ecotourism, landscape architecture and urban planning." CSA Illumina 1-2st ser. 25 (1993): 1-16. 26 Sept. 2005.

This article talks about the overlapping fields that have long attended to problems of conflicting values, aesthetics, recreation, and leisure. In it there are Guidelines for enhancing this framework to treat directly the special problems of ecotourism include early investigation of sociological and ecological features, involvement of

broker and local populations in the planning process, and extra-sensitivity to issues of site selection, design, scale, and monitoring.